



# SURGERY

## Gynecology and Obstetrics

An International Journal of Surgery

FRANKLIN H MARTIN, M D

*Founder and Managing Editor 1905-1935*

Volume 77

JULY TO DECEMBER, 1943

PUBLISHED BY

THE SURGICAL PUBLISHING COMPANY OF CHICAGO

54 EAST ERIE STREET, CHICAGO, ILLINOIS, U S A

LOYAL DAVIS, EDITOR

*Associates*

SUMNER L KOCH      MICHAEL L MASON

CONSULTING EDITORS

*UNITED STATES AND CANADA*

DONALD C BALFOUR	FRANK H LAHEY	W EDWARD GALLIE
VERNE C. HUNT	PHILIP D WILSON	FREDERIC A. BESLET
ALFRED BLALOCK	WILLIAM R. CUBBINS	WARREN H. COLE
ALFRED W. ADSON	ALBERT O SINGLETON	

*GREAT BRITAIN*

SIR JAMES WALTON	J. R. LEARMONTH	G. GREY TURNER
------------------	-----------------	----------------

---

<i>Argentina</i>	JOSÉ ARCE	
BENEDICTO MONTENEGRO	<i>Scandinavia</i>	EINAR KEY
<i>Australia</i>	SIR ALAN NEWTON	

COPYRIGHT BY THE SURGICAL PUBLISHING COMPANY OF CHICAGO, 1943

# CONTRIBUTORS TO VOLUME 77

ABELL, RICHARD G	348	FLAGG, PALUEL J	437	MCKENZIE, KENNETH G	631
ABELS, J C	16	FOSS, HAROLD L	673	MEIGS, JOE VINCENT	449, 557
ACKERMAN, LAURFN V	279	FREED, S CHARLES	605	MISRACK, MAURY	354
ADAMS, JOHN D	344	FREMONT SMITH, MAURICE	449	MOERSCH, HERMAN J	435
ALEXANDER, JOHN	219	IRIEDLANDER, MAE	162	MOORE, DONALD E	87
ALLEN, J GARROTT	126			MUIRHEAD, E C	113
ANGRIST, ALFRED	199	GILFILLAN, CHARLES	595	MURPHY, DOUGLAS P	101, 433
ARIEL, I M	16	GORDON, CHARLES A	26	MURPHY, FRANK C	397
ATLAS, LAWRENCE N	136	GRAHAM, HENRY F	674	MURRAY, GORDON	157
AUFSES, ARTHUR H	544	GRAHAM, RUTH M	449		
		GRISWOLD, R. ARNOLD	167, 601	NECHELES, H	337, 471, 475
	556	GUIDOTTI, FRANK P	178	NETER, ERWIN	634
BADCOCK, W WAYNE	205			NEUHOF, HAROLD	544
BERMAN, J K	462	HARKINS, HENRY N	661	NEW, GORDON B	284
BLACK, B MARDEN	261	HERGER, CHARLES C	634	NEWTON, W H	539
BOOG, JANET M	315	HILL, J M	113		
BRADSHAW, HOWARD H	51	HINTON, J WILLIAM	243, 376, 481	O'DELL, L D	553
BROWN, WLBSTER H	581	HOOVER, M J	367	O'KEEFE, J J	615
BRUNSCHWIG, ALFANDER	618	HOUSER, ALAN D	205	OLSON, WILLIAM H	471
BUCH, IRWIN M	413	HOVIS, W F	553	O'NEILL, JAMES F	315
BUDD, JOHN W	530			ORTNER, ALVIN	167
BURTON, CLAUD C	193, 326	JANOTA, MARTHA	337, 475	OWENS, FREDERICK M, JR	126
BYARS, LOUIS T		JOHNSON, MITCHELL D	598		
		JUDD, EDWARD S	21	PACK, G T	16
CASALE, WALTER	243, 376, 481	JULIAN, ORMAND C	126	PAGE, IRVINE H	348
CHESLEY, I FOR C	261			PAYNE, ROBERT L	105
CLARK, D	216	KANTHAK, I RANK F	610	PEARL, FELIX	354
CLARK, SAM I	403	KAPLAN, NAOMI	199	PENBERTON, JOHN DEJ	462
CLERT, LOUIS H	615	KAPNICK, ISRAEL	449	PHANEUF, LOUIS E	209
COAKLEY, WALTER A	360	KENNEDY, ROGER L J	639	PIERSON, JOHN M	426
COLETTI, C J	178	KEY, J ALBERT	389	PINCOCK, DOUGLAS F	493
COOK, EDWARD N	330	KURTZ, WILLIAM A	205	POPPER, H L	471
COOLEY, F F	615			POSNER, A CHARLES	618
COONSE, ALANNETH	344	LAHEY, FRANK H	331	POSTLETHWAITE, R W	397
COOPER, I REDFRICK W, JR	271	LAMBROS, V	216	PRESCOTT, FREDERICK	645
COOPER, WILLIAM GRANT, JR	279	LAPIDUS, PAUL W	178	PRESSMAN, JOEL JAY	421
COWLEY, LLOYARD L	661	LARSEN, BERNARD B	187	PRIESTLEY, JAMES T	21, 205
CROTTY, JOSEPH G	130	LASH, A I	576	PROBSTEN, J G	660
		LAUFMAN, HAROLD	605		
DAVIS, LOVAL	561	LEVINSON, S O	337, 475	RAPPAPORT, H	576
DE CHOLNOKY, TIBOR	55	LIVINCSTON, H	210	RAWSON, RULON W	449
DEERA, EDWIN M	70	LOCALIO, S ARTHUR	243, 376, 481	RHOADS, C P	16
DENNIS, CLARENCE	25	LOVE, J GRAFTON	497	ROGEFS, NEIL	561
DE TAKATS, GEVA	31	LOWSLEY, OSWALD S	91	ROSENTHAL, ALEXANDER H	26
DICKINSON, MURFIDITH	561	LYFORD, GEORGE	130	RYAN, WILLIAM JOHN	535
DIX, CHRISTOPHER R	284	LYON, ROBERT A	657		
DODD, HAROLD	645			SAMIT, JAMES H	250
DRACSTEDT, LESTER R	126	MACAUSLAND, W RUS-FIL	141	SANO, MACHTELD L	510
		MACDONALD, IAN	413	SAUPP, HANS R	634
ELKIN, DANIEL C	271	MARSHALL, VICTOR F	585	SCARF, JOHN I	561
EVANS, FARRITT INDIS	367	MAY, HANS	523	SCHLOSS, STUART A	130
		MCDONALD, JOHN R	205	SCHNELFES, I PANZ C	69
IRL, IRIDFRICK A	284				



SEUTELA, H. R.	669	THOMAS, HERBERT	53	WENTON, R. E.	337	47
SHACKELFORD, RICHARD T.	5	TOWSEND, KENNETH	505	WINTON, GORDON	307	
SHRYOCK, E. HAROLD	3 9			WHITE, MALTON F.	360	
SILBERT, SAMUEL	16	WAGENET, G.	330	WHITE, WILLIAM A. J.	514	
SLOCUM, DONALD B.	87			WOLCOTT, W. EDWIN	6	
SPENCER, NORMAN W.	3 9	WALKER, M. TRICK D.	497	WU, P. TACK P. T.	74	
SPITZEL, ROSE	6	WARD, JAMES W.	493			
STEVENS, ALEXANDER R.	535	WEISER, HARRY M.	630	YOCUM, CHARLES S.	3 8	
		WETZMAN, A.	337	YOCUM, HENRY H.		
THOMAS, KURT H.	40	WILLMAN, V.	6			

# SURGERY

## GYNECOLOGY AND OBSTETRICS

*An International Magazine, Published Monthly*

VOLUME 77

JULY, 1943

NUMBER I

### PERINEAL PROSTATECTOMY VERSUS TRANSURETHRAL RESECTION FOR HYPERTROPHY AND CANCER OF THE PROSTATE

HUGH H. YOUNG, M.D., F.A.C.S., Baltimore, Maryland

AS the author of the original instrument for urethroscopic transurethral prostatic resection which now, in one form or another, has been used in thousands of cases, I hesitate to take a stand against the widespread use of this procedure in all types of hypertrophy of the prostate, but I deem it high time to bring forth certain facts and experiences which I believe should be more generally known.

Soon after the presentation of my "urethroscopic prostatic excisor," and the revelation that certain cases of prostatic obstruction, by its use, could be quickly relieved of chronic urinary obstruction in 1909 (4) I was tempted to extend its use from small bars and contractures at the vesical neck to greater and greater enlargements of the prostate. In these cases the frequent occurrence of troublesome hemorrhage deterred me until in 1911 I had constructed in Berlin an electrocautery punch instrument with which the prostatic masses could be removed by an electrically heated loop. Later I employed fulguration to stop actively bleeding vessels. But even with this more effective instrument the results did not satisfy me in cases of pronounced pro-

static enlargement. I was forced to admit that a clean, thorough, quick enucleation of prostatic lobes through the perineum gave better results, and that the open operation was equally free from danger and far more permanent in its results.

John R. Caulk, who had worked with me during the development of these transurethral instruments, brought out his cautery punch instrument in 1921. This was a distinct improvement upon mine and could more effectively remove large prostatic masses transurethraly. Caulk soon became a great enthusiast for his transurethral instrument and proclaimed it to the world as the ideal procedure for prostatic hypertrophies, large and small. He followed his first announcement by other papers, and his reports greatly impressed the surgical world.

In the meantime, the modification of my instrument by William F. Braasch was materially improved by Bumpus, whose cases of prostatic hypertrophy in which he used my cold cutting knife added to the widespread interest in the transurethral attack upon the prostate.

Contemporaneous with the urologists mentioned came Stern (1926) with his fenestrated instrument, similar to my punch instrument,

From the James Buchanan Brady Urological Institute, Johns Hopkins Hospital

but provided with an electric loop and a cystoscopic observation sheath, to which he gave the name of resectoscope. The instrument was improved in 1928 by Theodore Davis who finally reported a long series of cases. Then in 1932 Joseph McCarthy brought out his instrument, a modification of Stern's in that he left off my fenestra. This has been the resectoscope employed most widely. In 1933 Gershom Thompson added to the Braasch Bumpus modification of my cold cutting fenestrated punch instrument an extra tube for a fulgurating wire to stop hemorrhage. Since then Thompson has made repeated publications of hundreds of cases, demonstrating the simplicity and efficacy of the cold "punch" and the remarkably low mortality following its use. Thompson became so enthusiastic over his results that soon he was proclaiming that by means of this instrument a really complete prostatectomy could be carried out transurethraly so much so that he dropped the title of resection and called the procedure transurethral prostatectomy.

Thousands of prostatitis now have been subjected to transurethral operations and their cases reported in medical journals. In many of these articles it has been stoutly asserted by some resectionists that the ideal operation for the treatment of prostatic obstruction large and small benign and malignant has been found and that for freedom from complications and splendid ultimate results, all open operations are definitely inferior and outmoded. Others frankly have acknowledged many shortcomings and fallures of transurethral prostatic resection admitting a mortality of 3 to 4 per cent and in the larger prostates an even higher death rate (1 3 5 7).

As the years have passed my feeling of paternal pride in the widespread use of transurethral resection has given way to a realization that the enthusiasm displayed for this type of surgery upon the obstructive prostate has gone too far, that the transurethral operation is not entirely free from danger, that the postoperative period is not so brief as is often asserted, that more or less prolonged convalescence is necessary before the deep masses

of burned tissue or eschar come away, and healing of the extensive intraprostatic wound occurs that incontinence which has been held up as the *bête noire* of the perineal operation actually occurs more frequently after transurethral resection and finally that recurrence of obstruction or painful infections of the remaining prostatic tissue and even calcareous incrustations often bring patients seeking relief after 1, 2 and even 3 transurethral resections.

Having hided my time the moment seems opportune to assemble simple facts about the various methods of attacking prostatic obstruction and to weigh the different procedures in the balance and compare them. I have analyzed the case histories of all patients (now totaling 300 cases) who have come to the Brady Urological Institute complaining of imperfect results following transurethral resection elsewhere. Some of these were operated upon by resectionists of no great experience but others came from the largest clinics in the country, the resections having been done by operators of wide experience in the use of various instruments which included the cold cutting punch instruments of Young, Braasch Bumpus, and Thompson, the cautery punch instrument of Caulk, and the electrified loop resector of Stern and McCarthy.

The multiplicity of problems presented by these patients can best be described by dividing the cases into various groups: (1) benign hypertrophy in which prostatic lobes weighing from 50 to 100 grams were enucleated by perineal prostatectomy; (2) benign hypertrophy in which prostatic lobes weighing from 100 to 200 grams were enucleated; (3) benign hypertrophy in which prostatic lobes weighing over 200 grams were enucleated; (4) benign hypertrophy in which less than 50 grams were enucleated; (5) imperfect results after resection but prostatectomy not indicated; (6) cancer of the prostate too advanced for radical operation; (7) cancer of the prostate in which radical operation seemed to offer a possibility of cure.

One or more transurethral resections elsewhere hypertrophied lobes weighing between 50 and 100 grams were enucleated. In order to prevent the aged symptom of which these patient



Fig 1 Path No 9973 Lobes enucleated perineally, with relief of frequency and pain following transurethral resection which had been performed  $3\frac{1}{2}$  years previously. Weight, 55 grams



Fig 2 Path No 10,011 Lobes enucleated perineally, with relief of hematuria and complete retention of urine following transurethral resection 3 years before. Weight 60 grams

complained, it seems desirable to cite a brief abstract of illustrative cases

In the following case hypertrophied lobes weighing 55 grams were enucleated (Fig 1)

CASE 1 (B U I 25260) C E F, aged 70 years, underwent a transurethral resection elsewhere  $3\frac{1}{2}$  years previously. Following the operation he had marked frequency and severe burning on urination, and when I saw him he was voiding 7 times at night, and the urine often was tinged with blood. Examination showed a moderately enlarged prostate 40 cubic centimeters residual urine, no enlargement of the median but marked intraurethral lateral lobes. Urine cultures showed *Staphylococcus aureus*. Through the perineum I enucleated 2 large lateral lobes and a small subtrigonal lobe weighing in all 55 grams. Pathological report Benign hypertrophy. Convalescence was slow, the wound healed in 4 weeks and the patient was discharged well. His physician reported  $2\frac{1}{2}$  years later that he was well.

In the next case hypertrophied lobes weighing 57 grams were enucleated, along with calculi weighing 10 grams

CASE 2 (B U I 29213) C B M, aged 70 years, underwent a transurethral resection elsewhere 2 years previously, and following operation he suffered from severe infection of the bladder, dysuria, and hematuria. On examination here he had 42 cubic centimeters residual urine. Hypertrophied lobes weighing 57 grams were enucleated perineally along with calculi which weighed 10 grams. Pathological report Benign hypertrophy and severe prostatitis. The immediate result was excellent. The patient was discharged on the 19th day. The wound had healed and he was voiding normally. His physician reported  $2\frac{1}{2}$  years later that the patient was well.

In the next case hypertrophied lobes weighing 60 grams were enucleated (Fig 2)

CASE 3 (B U I 25408) P B, aged 75 years, underwent transurethral resection elsewhere 3 years previously. On admission here he complained of occasional attacks of retention and intermittent hematuria. The prostate was considerably enlarged. The median lobe had been removed but rounded laterals were left behind at the transurethral resection. The residual urine was 25 cubic centimeters. Cultures of the urine showed proteus. A perineal prostatectomy was done by Dr Colston and prostatic lobes weighing 60 grams were removed. Pathological report Benign hypertrophy and chronic prostatitis. Urethral catheter drainage was employed. Convalescence was smooth until the 12th postoperative day, when feces suddenly escaped through the perineal incision. The patient left the hospital in 5 weeks. He was voiding freely, with good urinary control.

In the next case the patient complained chiefly of incontinence. Hypertrophied lobes weighing 60 grams were enucleated.

CASE 4 (B U I 26051) M J B, aged 74 years, continued to have marked hesitation, frequency and burning as well as dribbling, for 4 years following transurethral resection elsewhere. He had 50 cubic centimeters residual urine. By means of perineal prostatectomy lobes weighing 60 grams were enucleated. Pathological report Benign hypertrophy and chronic prostatitis. The wound healed promptly. The patient was discharged on the 21st day, voiding freely, completely relieved of the pain, but the incontinence (which had followed transurethral resection) was still present. Six weeks later his general condition was excellent. Urinary control was better, but he still had a slight drip.

In the next case hypertrophied lobes weighing 62 grams were enucleated.

CASE 5 (B U I 25672) J L K, aged 67 years, had had marked frequency of urination for 8 years.

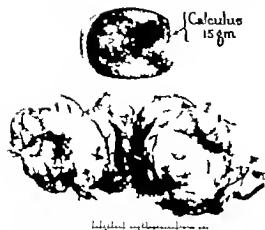


Fig. 5 Path. No. 977. Lobes enucleated perineally and also calculi. With relief of frequency and pain both followed transurethral resection years previously. Weight, 8 grams. Weight of calculus in ureter, 5 grams.

H. had undergone transurethral resection here, once 6 years and the second, 4 years before admission but the dysuria and marked frequency continued. On examination here the prostate was greatly enlarged. The residual urine was 45 cubic centimeters. Cultures showed *Escherichia coli*. A small median lobe was present and the lateral lobes markedly enlarged. D. Colston carried out perineal prostatectomy and lobes weighing 6 grams were enucleated. Pathological report: Benign hypertrophy of chronic prostatitis. The patient was discharged on the 5th day. The wound healed with result excellent.

In the next case hypertrophied lobes weighing 65 grams were enucleated and also multiple prostatic calculi were removed.

Cas. 6 (B.U.I. 32435) A.H. aged 64 years, had had prostatic trouble for many years, and 4 years before admission here he underwent transurethral resection elsewhere. The result was imperfect. Occasionally the passage of urine was as required. Recently he had marked hematuria and complete retention. Examination here showed that the prostate was markedly enlarged. Cystoscopy showed hypertrophied trigone and markedly enlarged bladder. B. perineal prostatectomy. I enucleated prostatic lobes weighing 65 grams. Pathological report: Benign hypertrophy, chronic prostatitis, and multiple calculi. Concomitance was satisfactory and when the patient was discharged on the 10th day he was feeling normal.

In the next case hypertrophied lobes weighing 69 grams were enucleated.

Cas. 7 (B.U.I. 361) W.C., aged 60 years, underwent a transurethral resection 2 years previously because of frequency and difficulty of urination. Following the operation he had severe bleeding when he returned home and on admission here he suffered from marked nocturia, difficulty and dribbling and partial incontinence. Examination showed that the prostate was greatly enlarged. Culture of the urine showed *Escherichia coli*. Cystoscopy disclosed no residual urine but considerable prostatic hypertrophy was present. B. perineal prostatectomy. Lobes weighing 69 grams were removed. Pathological report: Benign hypertrophy. The patient was discharged on the 10th day in splendid condition. 11 years later he reported that he was voiding well at normal intervals, but that the partial incontinence which had followed the transurethral resection was still present.

In the next case hypertrophied lobes weighing 72 grams were enucleated.

Cas. 8 (B.U.I. 7452) W.L.B. aged 64 years, had had frequency and difficulty of urination 7 years before admission here and he underwent transurethral resection elsewhere. The burning and dysuria, however, continued after operation. On admission here he had marked frequency and chronic epididymitis. Culture of the urine was sterile. The residual urine was 50 cubic centimeters. The bladder capacity was 200 cubic centimeters. Examination showed greatly enlarged prostate. By perineal prostatectomy D. Lloyd Lewis removed median and lateral lobes in pieces weighing 7 grams. Pathological report: Benign hypertrophy. The patient was discharged on the 4th day voiding freely with good control. The wound healed. On examination 3 months later his condition was excellent, he voided once at night and had no pain, hematuria, or difficulty.

In the next case hypertrophied lobes weighing 81 grams were enucleated (Fig. 3).

Cas. 9 (B.U.I. 30) C.S. aged 65 years, underwent transurethral resection elsewhere nearly 7 years previously. Following the operation he had persistent burning, urgency and frequency and nocturia 7 times. Examination here showed that the prostate was markedly enlarged and that there were calculi in the bladder. The prostate was infected. It was impossible to introduce cystoscope because of the large calculi and the greatly contracted bladder which held only 5 cubic centimeters. D. Samuel A. Vest carried out perineal prostatectomy. A calculi nearly 1 inch in diameter and lobes weighing 8 grams were removed. Pathological report: Benign hypertrophy. The patient was discharged on the 9th day. The wound healed. He was voiding normally and had complete urinary control. The result of the operation was excellent. He did not become recalcitrant but he was not returned.

In the next case hypertrophied lobes weighing 85 grams were enucleated (Fig 4)

CASE 10 (B U I 28038) R C McQ, aged 53 years, had had difficulty and frequency, which began 9 years previously. Subsequently he had pain and hematuria. Four years ago he underwent transurethral resection elsewhere, but without improvement. One month after the first operation a second transurethral resection was done elsewhere but still the burning and pain persisted. Three years after the second resection a third was done elsewhere following which the patient had severe hemorrhage and epididymitis. A fourth transurethral resection performed elsewhere, was not effectual in relieving the symptoms. On admission here he complained of difficulty, hesitancy, diurnal incontinence, pain, infected urine, epididymitis, stricture of the urethra, and impotence. The prostate was not enlarged by rectum, but cystoscopy showed an anterior lobe hanging over the orifice. The residual urine was 80 cubic centimeters. Dr Lloyd Lewis carried out perineal prostatectomy and removed 2 large lobes weighing 85 grams. Pathological report: Benign hypertrophy and chronic prostatitis. The patient was discharged on the 17th day. The wound had healed and urination was normal; the pain on urination had disappeared. Three years later he reported that urination was normal, the pain had been relieved, and his urinary control was better.

In the next case hypertrophied lobes weighing 91 grams were enucleated

CASE 11 (B U I 27616) L S, aged 65 years, had sudden retention of urine 3 years before admission and required catheterization occasionally thereafter. He underwent a transurethral resection elsewhere 8 months before admission here but he was not relieved of his symptoms. When we saw him he complained of marked dysuria, dribbling and difficulty. Examination showed a greatly enlarged prostate. He had 150 cubic centimeters of residual urine and the bladder was contracted. The bladder capacity was 275 cubic centimeters. A large lateral and an irregular median lobe were present along with marked bilious edema of the bladder mucosa. The urine was infected. Dr John Dees carried out perineal prostatectomy and enucleated 3 lobes in 2 pieces weighing 91 grams. Pathological report: Benign hypertrophy and chronic prostatitis. The patient was discharged on the 16th day. The wound was healed, urinary control perfect and he was voiding freely at intervals of 3 hours. Examination 4 years later showed that the patient was well.

2. *One or more transurethral resections elsewhere. Hypertrophied lobes weighing between 100 and 200 grams enucleated.* In the first case hypertrophied lobes weighing 102 grams were enucleated.



Fig 4 Path No 12,024 Lobes enucleated perineally with relief of pain, difficulty and incontinence which followed four transurethral resections previously. Weight, 85 grams

CASE 12 (B U I 30670) C A P, aged 61 years, had frequency and burning on urination which began 11 years before admission here. A transurethral resection had been done on him 5 years ago. His symptoms were relieved for 6 months, and then returned. On admission here he had complete retention and was wearing a catheter. The prostate was greatly enlarged. The urine was infected. The residual urine was 300 cubic centimeters. I carried out perineal prostatectomy and enucleated in 1 piece hypertrophied lobes weighing 102 grams and measuring 3 inches in diameter. Pathological report: Benign hypertrophy. The patient was discharged on the 21st day, voiding normally. One year later he returned for examination. Urination was normal and he could go 8 hours without voiding. The urine was clear and cultures were sterile. He had cotus frequently.

In the next case hypertrophied lobes weighing 104 grams were enucleated (Fig 5)

CASE 13 (B U I 26475) H N M, aged 60 years, had urinary frequency for 3 years before admission here. A transurethral resection was done elsewhere 2 years previously but marked frequency, burning and intermittent hematuria continued and a second transurethral resection was done elsewhere 1 year later but with no improvement. On admission here he complained of severe burning on urination, nocturia every 15 minutes, and occasionally hematuria. He had incontinence by night and dribbling by day. Examination showed that the prostate was very large. The urine was infected. Cystoscopy showed intravesical enlargement of both lateral lobes. In place of the median lobe there was a deep granulating area extending from the urethra into the bladder with marked edema of the vesical mucosa completely obscuring both ureteral orifices. By perineal prostatectomy



Fig 5. Path. No. 413 Lobes enucleated perineally with relief of frequency, hematuria, and pain which followed two transurethral resections, and years previously weight, 0.3 grams.

Fig 5. Path. No. 413 Lobes enucleated perineally with relief of frequency, hematuria, and pain which followed two transurethral resections, and years previously weight, 0.3 grams.

D Lloyd Lewis enucleated 3 lobes weighing 0.3 grams. Pathological report: Benign hypertrophy of chronic prostatic tissue. The patient was discharged on the 31st day voiding normally and with good urinary control. Did not answer letter but it was not returned.

In the next case hypertrophied lobes weighing 115 grams were enucleated (Fig 6)

CASE 4. (B.U.J. 938) J.H.A., aged 77 years, had prostatic obstruction which was treated by transurethral punch operation 8 years previously. Two years after the first operation another transurethral procedure was done with no relief of symptoms. Five years later he had an attack of severe hematuria which was treated by transurethral cauterization. 10 months before admission here the patient had another attack of severe bleeding and when I saw him he complained of urgency, frequency every 15 hours, and burning. The prostate was greatly enlarged. The residual was 50 cubic centimeters and the urine infected. On cystoscopy the median lobe had been completely removed, but large lateral lobes remained. I carried out perineal prostatectomy, enucleating in pieces hypertrophied mass which weighed 115 grams. Pathological report: Benign hypertrophy. I da the wound as healed. The patient was discharged on the 16th day voiding normally. On examination 3 years later the patient voided normally. He could go 6 hours at night without urinating. He had half an hour after operation he reported better than usual, normal and that he had had no more attack of hematuria.

In the next case hypertrophied lobes weighing 174 grams were enucleated (Fig 7)

CASE 5. (B.U.J. 5100) J.C., aged 7 years, had acute retention, for which suprapubic cystostomy as performed elsewhere. Two weeks later a transurethral resection was carried out 56 grams of tissue being removed. Following operation the patient became delirious and began to have marked pyrexia, high count and daily. The transurethral resection failed to relieve the obstruction. The suprapubic wound opened and a second resection as performed 6 grams of tissue being removed. After that the patient had prolonged fever and unable to void. When I saw him the prostate as found to be greatly enlarged. He continued to have a high temperature every day. Cystoscopy showed anterior lobe, lateral lobes which projected into the bladder and, behind these evidence that much tissue had been resected. A perineal prostatectomy was carried out by D. Lloyd Lewis, and 3 very large lobes weighing 174 grams were enucleated. Following operation the patient had more fever and blood cultures showed streptococcus infection. Various types of chemotherapy are employed without sterilization of the blood being obtained. The perineal wound healed in 3 weeks, and on discharge the patient was voiding normally. The daily pyrexia continued. Several weeks after leaving the hospital he died of pulmonary embolism.

### 3. Transurethral resection elsewhere large prostatic lobes weighing 235 grams enucleated

CASE 6. (B.U.J. 3447) W.W.H. had symptoms of prostatic obstruction 1 year previously. Nine years ago he underwent transurethral resection elsewhere. He was asymptomatic for 3 years and then frequency pain and terminal hematuria developed. Recently he required catheterization and on admission here he was suffering greatly. Rectal examination disclosed huge prostatic hypertrophy.



Fig 6. Path. No. 379 Lobes enucleated perineally with relief of marked frequency, burning, and hematuria which followed two transurethral resections previously. Weight, 174 grams.

Fig 6. Path. No. 379 Lobes enucleated perineally with relief of marked frequency, burning, and hematuria which followed two transurethral resections previously. Weight, 174 grams.

The residual urine was approximately 250 cubic centimeters. Cystoscopy showed a very great enlargement of the intravesical and intraurethral prostatic lobes. I carried out perineal prostatectomy, enucleating greatly enlarged lateral and a median lobe in 1 piece weighing 235 grams (Fig 8). Pathological report: Benign hypertrophy. The patient was discharged on the 22d day, the wound was closed, urination was normal at intervals of 2½ hours and he had no discomfort. Six months later the patient reported that he was well.

4. *One or more transurethral resections elsewhere, hypertrophied lobes weighing less than 50 grams enucleated, but various symptoms, such as pain, irritation, burning, dysuria, straining, frequency and calculi had followed transurethral resection.* I shall cite brief abstracts of 19 of these cases.

CASE 17 (B U I 24804) S B, aged 60 years, had been subjected to 3 transurethral resections elsewhere, yet on admission here he had 50 cubic centimeters residual urine, intractable pyuria with chronic infection of the bladder and urethra. The tissue removed by perineal prostatectomy showed both hypertrophy and prostatitis. Although the specimen weighed only 37 grams, an excellent result was obtained and the patient lived for 5 years in comfort. He died from a heart attack.

CASE 18 (B U I 30365) T V S, aged 65 years, had suffered from difficulty and frequency of urination since a transurethral resection elsewhere, 5 years previously. Prostatitis was marked in the enucleated lobes which weighed only 15 grams. It is now 2 years since operation. The urine is sterile, and the result excellent.

CASE 19 (B U I 27406) R A T, aged 49 years, had had frequency, urgency and pain for 2 years

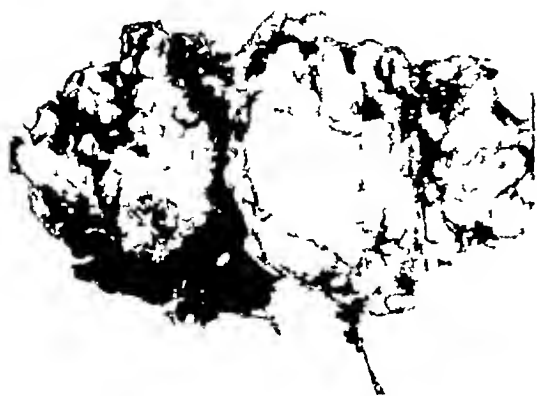


Fig 7 Path No 9874. Lobes enucleated perineally, with relief of complete retention which followed two transurethral resections previously. Weight, 174 grams.



Fig 8 Path No 12,613. Lobes enucleated perineally, with relief of complete retention, pain and hematuria which followed transurethral resection 6 years previously. Weight 235 grams.

following transurethral resection elsewhere. The residual urine was 50 cubic centimeters. There was no infection present and only a small amount of tissue was enucleated by a perineal prostatectomy, but the patient reported a year after operation that he had been completely relieved. Urination was normal.

CASE 20 (B U I 26601) E Z, aged 60 years, 3 transurethral resections elsewhere had failed to give relief from marked frequency, burning, and pain. He had a pronounced urinary infection, and 150 cubic centimeters residual urine. The tissue removed weighed 45 grams and showed marked prostatitis in addition to benign hypertrophy. Four years after perineal prostatectomy the patient reported that urination was normal, that he was relieved of the pain and was well.

CASE 21 (B U I 25967) J R, aged 57 years, 4 transurethral resections had been done, the last one 2 years previously, but the patient still had marked frequency, difficulty, and burning. Two additional transurethral resections failed to afford relief. Although there was only 25 cubic centimeters residual urine and the amount of tissue removed by perineal prostatectomy weighed only 19 grams, marked prostatitis was present in microscopic sections. The patient was completely relieved and 6 years later, his physician reported that he was enjoying splendid health and urination was normal.

CASE 22 (B U I 31673) A transurethral resection elsewhere 4 years previously had afforded only temporary relief, and he had had to resume a catheter life. The lobes enucleated perineally weighed 39 grams. The patient reported 1 year



transurethral resection instead of by prostatectomy. In many of these however experienced operators had failed to obtain satisfactory results by one two and sometimes three transurethral resections. In others the prostate was so markedly enlarged that to remove all or nearly all of the hypertrophied lobes by transurethral resection would have required a prolonged resection, and in a few cases probably several resections. In these cases exposure of the prostate through the perineum and relatively quick enucleation completely removing all the hypertrophied tissue and a surgical closure of the wound by anastomosing the mucosa at the vesical neck with the urethra below seemed to be so much more scientific than the open operation was chosen. The good results justified the choice.

In other cases, in which the remaining prostatic obstruction was not very great transurethral resection might have been successfully repeated (although in some instances two or more already had been done elsewhere). In the majority of these patients the principal symptoms were dysuria, pain, burning and pyuria, resulting from chronic infection and, in many cases, severe prostatitis was present. Removal of the infected tissue as well as the obstruction seemed preferable to another resection and the results have justified the choice.

*5 Analysis of 87 cases in which various symptoms persisted after transurethral resection elsewhere but prostatectomy was not done here.* The time elapsed since transurethral resection elsewhere was under 6 months, 12 cases; between 6 and 12 months, 13 cases; between 12 and 18 months, 14 cases; between 18 months and 2 years, 15 cases; between 2 and 3 years, 12 cases; between 3 and 4 years, 8 cases; between 4 and 5 years, 8 cases; between 5 and 6 years, 7 cases; between 6 and 7 years, 2 cases; over 7 years, 6 cases.

The immediate results obtained by transurethral resection were stated in the history in 63 cases improved, 33 cases not improved 30 cases.

The symptoms of which the patient complained on admission to the Brady Urological Institute were: marked frequency of urine 54 cases; difficulty of urination 33 cases;

urgency of urination 17 cases; pain, principally in the urethra and bladder 29 cases; burning in the urethra or bladder 18 cases; hematuria, 7 cases; dribbling (not amounting to true incontinence) 8 cases; complete incontinence 6 cases.

The effects on the sexual powers were tabulated in some of the cases. One patient was completely impotent 7 said that there was no ejaculation accompanying the orgasm 5 complained that coitus was markedly impaired 3 had pain on ejaculation. In 3 cases the ejaculatory ducts were found to be strictured on probing them through the urethroscope. One complained of painful erections.

The size of the prostate was definitely stated in 69 cases. On rectal examination it was described as enlarged in 25 cases, slightly enlarged in 27 cases, moderately enlarged in 10 cases, considerably enlarged in 5 cases and very greatly enlarged in 1 case. Induration of the prostate was a pronounced feature in 19 cases.

In many cases it was impossible to get prostatic secretion by massage but in 25 cases markedly purulent secretion was obtained.

Structure of the urethra was noted in 7 cases.

Cystoscopy was carried out in 64 cases. No residual urine was found in 30 cases; from 20 to 49 cubic centimeters, 6 cases; 50 to 99 cubic centimeters 8 cases; over 1,000 cubic centimeters 1 case. The bladder capacity was noted in 23 cases. In 2 cases it was reduced to 100 cubic centimeters; in 4 cases to 200 cubic centimeters; in 17 cases it was over 300 cubic centimeters. A description of the cystoscopic appearance of the vesical neck or the prostatic urethra is available in 32 cases. In 4 there was no evidence of obstruction. In 1 there was a pronounced contracture. In 4 one or more definitely obstructive prostatic lobes was discovered and in 6 very considerable lobular enlargements were seen. In 7 cases it was merely noted that obstruction at the vesical orifice remained following transurethral resection.

Cultures were not always made from the urine. In 17 the cultures were pronounced sterile. In 17 it was simply noted that infection was present. In 23 cases a pronounced

infection was discovered, and in 5 very severe infection was revealed by the cultures. The infecting agent was bacillary in character in the majority of cases, the colon group predominating. In many cases *Bacillus proteus*, and in a number of cases *pyocyaneus* was the most important organism. *Staphylococci* and *streptococci* were often present in conjunction with bacilli, but were sometimes alone. Stones were discovered in the prostate in 3 cases.

Large vesical diverticula were present in 1 case.

In 16 cases 2 transurethral resections had been carried out before the patient was admitted to our clinic. In 2 cases the fourth resection had been done without benefit. In 4 cases transurethral resection to effect a cure of the obstruction, which we found present, was carried out at our clinic.

Suprapubic drainage had been done on 4 patients either before or after transurethral resection elsewhere.

In 1 case the patient complained of very severe vesical pain. Pronounced bullous edema was discovered on cystoscopy. In 5 other cases severe inflammatory conditions of the bladder were present, usually an unhealed ulcer at the neck of the bladder and trigone. In 1 case submucous ulcers requiring resection were present. In 1 case presacral neurectomy also was carried out with good result.

*Summary.* These 87 patients, who had been subjected to 1 or more transurethral resections elsewhere, came to us with various complaints, the most common being frequency of urination in approximately 70 per cent, and pain or severe burning in 72 per cent. Difficulty of urination was present in 37 per cent. In many cases the local symptoms were distressing and often caused by severe infection of the bladder and urethra, in other cases, pain and burning due to inflammation in the remaining prostatic tissue, which often had been incompletely resected, were responsible for many of the symptoms. These often were associated with frequency and difficulty that sometimes were so severe as to cause marked discomfort. Transurethral resection had been effective in doing away with residual urine in 34 per cent. Among the 64

patients upon whom cystoscopy was performed, about 46 per cent showed no residual urine. In 54 per cent residual urine was present, varying from 50 to 150 cubic centimeters in over half of these cases and reaching somewhere between 300 and 1000 cubic centimeters in 9 cases (14 per cent).

*6 Twenty-six cases of cancer of the prostate, 1 or more transurethral resections elsewhere, lesion too far advanced on admission here for the radical operation.* Five of these patients had been subjected to 2 transurethral resections, 1 to 4 resections. In 8 cases from 1 to 8 years had elapsed since the resection. It seems evident that during this period of time a careful rectal examination should have revealed cancer of the prostate early enough for the radical operation.

In many of these cases the patients obtained temporary or prolonged improvement, but in 13 cases no improvement apparently followed transurethral resection, and 1 patient became worse. On admission here 3 patients appeared to be completely relieved of symptoms. They were sent by their physicians to see whether a radical operation was possible.

In 18 cases the patient complained of marked frequency of urination, in 11, difficulty, in 7, urgency, in 2, catheterization was necessary. In 10 cases severe pain, localized in the urethra, bladder or prostate was present. In 9 cases referred pains, generally in the back, were present. In 4 cases marked burning on urination occurred, in 6 cases hematuria was a prominent symptom and in 3 cases, pyuria. The patient complained of dribbling in 3 cases, and in 4 cases complete incontinence was present. On rectal examination the whole prostate was involved in 24 cases. In 2, only a portion of the prostate was involved. The seminal vesicles were involved in 22 cases, the periprostatic tissue in 10 cases, the membranous urethra in 13 cases. Enlarged glands were made out high up in the pelvis in 2 cases. The rectum was invaded in 3 cases. In one of these a rectourethral fistula was present. Stricture of the urethra was noted in 1 case, but probably was present to a certain extent in many other cases. In 7 cases the resectionist was surprised to find cancer in the microscopic examination of sec-

tions from the tissue removed by transurethral resection. Examination of all these patients showed that they were too far advanced for radical operation when they came to us. Other cases in which the carcinoma was not so advanced and in which we thought it would be possible to obtain cures by my radical operation are not included here but are reported farther on in this paper. An x-ray picture was not taken at our clinic in a considerable number of cases in which the carcinoma was found to be very extensive. In 7 cases an x-ray examination showed no evidence of metastasis. In 5 metastasis to the bones was present and in 2 cases the bony changes were suspicious. In some cases no treatment was given to the patient at our clinic. In 1 case radium was administered to the carcinomatous prostatic urethra by means of an applicator. In 4 cases 1 or more courses of deep x-ray therapy were given. In 7 cases orchidectomy was done. In 4 cases another transurethral resection to remove obstructions were carried out at our clinic. Two cases, in which 2 transurethral resections had been done elsewhere but in which we discovered carcinoma of the bladder (and not of the prostate) are omitted from this list. One of these patients was subjected to ureteral transplantation and total cystectomy and prostatectomy with improvement for several months.

*7 Cases previously treated by transurethral resection elsewhere. Cancer of prostate found in microscopic examination of tissue. Cases thought not too advanced for cure by radical operation which was done.* In this group there are 4 cases of cancer of the prostate in which we decided to carry out my radical operation with the hope either of obtaining a radical cure or at least removing the carcinomatous mass and affording the patient relief from distressing obstructive symptoms and possibly freedom from local recurrence.

**CASE 36 (B.U.I. 5485)** M. H. B. aged 5 years, had had frequency and urgency for 34 years. Eight weeks previously he underwent transurethral resection elsewhere. Sections revealed cancer. Examination here showed the prostate to be slightly enlarged, the right lobe irregular and very hard, the right vesicle involved, and the prostate fixed. Young's radical operation for cancer of the prostate

was carried out, removing in pieces the prostate with its capsule, a portion of the membranous urethra, a cuff of the bladder, both seminal vesicles and the ampullae. The bladder was sutured to the stump of the membranous urethra. Pathological report: Cancer of prostate involving seminal vesicles. The prognosis for radical cure is poor. The wound healed promptly. The patient had almost complete urinary control on discharge. Four months later rectal examination showed no local recurrence or obstruction and normal urination but an x-ray picture disclosed bony metastases. The patient died a year later. The radical operation had afforded complete local relief and a comfortable life for year.

**CASE 36 (B.U.I. 566)** E. B. aged 63 years, had had difficulty and frequency for 7 years. He underwent transurethral resection elsewhere 4 years ago with temporary relief. On admission here he had marked hesitancy and straining. The prostate was moderately enlarged and very hard. The seminal vesicles apparently were negative. An x-ray film showed no evidence of metastases. D. Wyland Leadbetter carried out a radical perineal prostatectomy (Fig. 9). Pathological report: Cancer apparently of involving the seminal vesicles. The prognosis was favorable for radical cure. Convalescence was satisfactory. The patient voided naturally on the 15th day, the wound was dry on the 20th day. The next day he was discharged. He voiding urine at normal intervals with good control. Ten years later the patient was apparently well.

**CASE 37 (B.U.I. 549)** T. E. S. aged 67 years, had obstructive symptoms 8 months previously. Complete urinary retention developed and transurethral resection was done elsewhere. The patient was much improved until short time before admission here, when he had marked difficulty and complete retention requiring catheterization. On examination the prostate was only slightly enlarged, but very hard, of third degree induration. Diagnosis: Cancer of prostate not involving the seminal vesicles and membranous urethra. X-ray films were negative for metastases. D. John I. Dees carried out radical perineal prostatectomy (Fig. 10). Microscopic examination of the tissue showed cancer. Convalescence was satisfactory. There was never any leakage through the perineum. He was discharged 4 weeks, voiding normally, with almost complete control. Ten months later he was voiding freely with good urinary control. Three years later he reported by letter that he was well and working every day on his farm.

**CASE 38 (B.U.I. 590)** D. M. O. aged 6 years, had hesitancy and difficulty of urination year before admission here. Six months ago he experienced marked difficulty in urinating. He consulted distinguished resectionist who carried out transurethral prostatectomy with the Thompson punch instrument, at which 5 grams of tissue were said to have been removed. The patient was told that microscopic examination showed cancer. Deep

x-ray therapy was instituted. The patient saw me at a meeting of the Interstate Post-Graduate Assembly in Chicago in October, 1939. Examination showed third degree induration of the entire prostate, evidently cancer. The radical operation was advised. I carried out radical removal of the prostate with the seminal vesicles and neck of the bladder. Pathological report: Adenocarcinoma of the prostate, the seminal vesicles apparently were not involved. Postoperative phlebitis kept the patient in the hospital 6 weeks. On discharge he was voiding normally through the urethra at intervals of 3 hours. He had slight incontinence which had been present since the transurethral resection. Three years later the patient reported by letter that he was well. He was voiding urine with good control, but a few drops leaked on coughing or sudden movement.

#### SUMMARY

This paper is not intended to present a complete picture of the results obtainable by transurethral resection. We have in the records of the Brady Urological Institute hundreds of case histories which testify to the relief of obstruction, frequency, difficulty, pain, and other symptoms presented by patients who have been successfully treated by transurethral prostatic resection either with my cold-cutting punch or one of its modifications, or with the electric resectoscope of McCarthy. The cases reported here are of those patients who complained of unsatisfactory results after one or more transurethral resections elsewhere.

I have first described those cases in which prostatic lobes had been left behind or developed after transurethral resection, removal of which by perineal prostatectomy afforded relief of the symptoms of which the patient complained. In some of these the transurethral operations had been manifestly inadequate. Often only the middle lobe was thoroughly resected and the laterals were incompletely removed. In many instances, however, the patients had obtained relief of obstruction for a time, but the remaining portions of the hypertrophied lobes continued to grow and ultimately produced marked obstruction to urination and other distressing symptoms.

In other cases these symptoms were greatly aggravated by the presence of infection, not only of the bladder and urethra, but of the remaining prostatic tissue. Chronic pro-

statitis appeared to be a frequent sequel of transurethral resection, and in most instances resisted all efforts at sterilization by modern chemotherapy, including the various sulfonamides. Annoying burning in the urethra or vesical neck, aggravated during micturition and sometimes amounting to severe pain, frequently was present.

In some cases in which no residual urine was found, the irritation was sufficient to produce very frequent micturition and even dysuria. In such cases a second and even a third transurethral resection had failed to do away with the distressing symptoms which followed the first resection.

In a few cases chronic ulceration of the floor of the urethra, extending back into the bladder, had persisted for many months after transurethral resection and occasionally was associated with bullous edema and an irritable, contracted bladder, in one case so severe that presacral neurectomy was necessary to afford relief.

In another case resection of the ulcerated portions of the bladder, in addition to presacral neurectomy, was required.

In a few cases vesical calculi were present, having recurred in one case after a second resection and removal of the stones. In some cases calculi in the tissue of the prostate gland itself were responsible for marked discomfort and the persistence of pyuria and infection. Perineal prostatectomy, by affording an opportunity to remove completely the stone-bearing prostatic tissue, finally gave complete relief.

A number of these patients had not been relieved by a second transurethral resection elsewhere but were promptly cured by enucleation of the obstructing infected lobes through the perineum. In some, equally good results might have been obtained by suprapubic enucleation. To have attempted again, by transurethral resection, to do a complete removal of the large prostatic lobes would have consumed a great deal of time and resulted in an incomplete operation, whereas much less time was required to do a thorough enucleation through the perineum, and by drawing down the mucosa below the vesical neck and suturing it to the remaining urethra, prac-

tically *per primam* healing was obtained, affording prompt restoration to normal micturition. Most striking is the fact that pyuria and severe persistent infection generally disappeared with the removal of the chronically infected and obstructive prostatic lobes.

These cases seem to prove conclusively that in prostates of considerable size, and even in some of moderate size an enucleating prostatectomy is a far more scientific procedure than chipping away the periurethral prostate bit by bit, and rarely removing all the adenomatous lobes completely. In some of these cases, even by prolonged transurethral procedures, it would have been impossible to remove the portions of the very large adenomatous lobes remote from the urethra, especially those which extended well beneath the trigone. To have attempted a complete removal in the latter cases by transurethral resection would have necessitated destruction of a large part of the trigone a condition which Rudnick showed to be sometimes the cause of a fatal ending.

But it is in the carcinomatous prostate that the routine use of transurethral resection in all cases with prostatism has its most direful results. In most of the cases of cancer reported here a considerable period had elapsed between the transurethral resection and the time that the patient came to us, with cancer of the prostate too advanced for the radical operation. In these cases the histories frequently disclosed that the patients had been treated for months before being subjected to a transurethral operation. A careful rectal examination should have warned of the presence of cancer at a time when it was well confined within the capsule of the prostate and the radical operation could have been carried out successfully. Even if the examination only aroused the suspicion of cancer by means of a perineal exposure and biopsy, accurate determination as to the presence of cancer could have been obtained and an appropriate operation done.

Previously in SURGERY GYNECOLOGY AND OBSTETRICS I described in detail the latest technique which I employ in the radical operation for cancer of the prostate. A careful review of all cases subjected to this operation

at our clinic shows that the technique is not difficult inasmuch as splendid results have been obtained by house officers doing their first prostatectomies. In fact, their record is almost the best of the staff. The operation itself in patients in anything like fair condition is relatively free from danger. We have had one series of 53 consecutive cases without a death and the operative mortality for all cases is 6 per cent. Incontinence no longer is a bugbear. By more careful placing of sutures between the bladder and the stump of the membranous urethra, so as not to ligate the musculature of the external sphincter normal micturition is obtained.

Reports from various clinics substantiate our claims that taken early cancer of the prostate is curable by the radical operation. In cases in which even the entire prostate was carcinomatous, and including those in which a small portion of the adjacent seminal vesicles were involved, radical cures have been obtained in over 50 per cent of our cases followed 4 years or longer.

When these facts are more widely appreciated by the medical profession many more cases of cancer of the prostate will be sent to competent urological surgeons sufficiently early for a radical cure. An encouraging sign is that already some general practitioners are recognizing that a very markedly indurated area in the prostate should be suspected of being malignant.

#### CONCLUSIONS

I believe a fair conclusion to be drawn from this study of the 200 patients who were subjected to one or more transurethral resections before coming to us is that for many cases, particularly those with considerably enlarged prostates complete enucleation of the hypertrophied lobes through the perineum gives better results and is no more dangerous than transurethral resection.

Prostatitis and painful urination are certainly less common after perineal prostatectomy than after transurethral resection.

Another great advantage of the perineal procedure is the opportunity which it affords to make a diagnosis and effect a cure of carcinoma of the prostate.

Undoubtedly many conditions, particularly bars, contractures and small hypertrophies, can be dealt with efficiently by transurethral resection. But in the larger hypertrophies, the patients with calculi in the prostate, and those with chronic prostatitis, my study of 200 cases shows that perineal prostatectomy is distinctly superior.

Prostatism is so complex in its symptoms and so varied in its pathology that it can be handled satisfactorily only by careful selection of the operative procedure best suited to obtain a radical cure.

The exclusive use of transurethral resection for all types of prostatic obstruction, even

the very large and the malignant, is indefensible.

#### REFERENCES

- 1 HINMAN, FRANK J Am M Ass, 119, 669 1942
- 2 RUDNICK, DORRIN F J Urol, 1935, 34 437-445
- 3 SMITH, GEORGE GILBERT J Am M Ass, 1942, 118 1514
- 4 YOUNG HUGH H Tr Am Ass Genito Urin Surg, 1909, 4 134-145 152-153
- 5 Idem Transurethral resection of the prostate A clinical and operative study, with exhaustive quotations from the literature In Nelson's Loose Leaf Surgery, 1937
- 6 Idem Surg Gyn Obst, 1937, 64 472-484
- 7 Idem J Am M Ass, 1942, 119 669
- 8 Idem Surg Gyn Obst, 1910, 28 84-90
- 9 YOUNG HUGH H and STONE, HARVEY B Tr Am Ass Genito Urin Surg, 1913, 8 270 278 Also J Urol, 1917, 1 289 317

# METABOLIC STUDIES IN PATIENTS WITH CANCER OF THE GASTROINTESTINAL TRACT

## VI Postoperative Hypoproteinemia and Relationship of Serum Protein Fall to Urinary Nitrogen Excretion

I. M. ARIEL, M.D. J. C. ABELS, M.D. G. T. PACK, M.D. F.A.C.S. and C. P. RHOADS, M.D.  
New York, New York

**I**N a previous investigation of this series (3) a high incidence of hypoproteinemia was found in patients with gastric cancer. In most instances this abnormality was due to an impaired albumin fabrication apparently induced by the presence of the tumor. The existence of hypoproteinemia in these patients was considered to be of noteworthy importance because they usually undergo prolonged surgical procedures. The postoperative complications which result from the hypoproteinemic state are known to include tissue edema (8), gastrointestinal hypomotility (4), increased susceptibility to infection (6) and poor wound healing (10).

During the last few years it has been the clinical experience of this hospital that the postoperative complications attributable to hypoproteinemia were encountered more frequently in patients with gastrointestinal cancer than in individuals with other disorders. This observation suggested that patients with cancer of the gastrointestinal tract were more prone to develop after operation seriously low levels of serum protein although the reason for that tendency was not apparent. Accordingly the present study was undertaken in order to ascertain whether or not (a) the serum protein levels of patients with gastrointestinal cancer fell after operation more frequently and to lower levels than did those of other groups of patients subjected to comparable surgical manipulation and (b) if this were so, was an increased protein catabolism responsible.

### CLINICAL MATERIAL

Three groups of patients were studied. In all, the diagnosis was confirmed by microscopic examination of biopsy sections.

Group I consisted of 47 patients with gastrointestinal cancer. Of these 3 had carcinoma of the esophagus, 36 of the stomach, 1 of the duodenum, 1 of the sigmoid, and 6 of the rectum. These patients were subjected to operative procedures which ranged in their gravity from simple laparotomy to complete resection.

Group II consisted of 9 patients with benign non-neoplastic disease of the gastrointestinal tract. Four had gastric ulcer, 3 suffered from gastritis, and 2 with duodenal ulcers.

Group III consisted of 9 women with gynecologic disorders. Of these 2 had cancer of the uterus, 5 had uterine fibroids, 1 had a dermoid cyst, and the last had a fibroid of the ovary. Seven were subjected to supracervical hysterectomy and 2 underwent oophorectomy.

### METHODS

*A Clinical.* All determinations of serum protein were made in duplicate on samples obtained from patients who were fasting and who were considered not to have hemoconcentration.

All the patients with gastrointestinal disorders were hospitalized for from 5 to 10 days before they were subjected to operation. During this time they were maintained on constant diets and were given from 2,000 to 3,500 milliliters of fluids daily. In the first 5 days after operation these individuals ingested a total of from 1,000 to 5,000 calories and from 35 to 150 grams of protein.

From The Memorial Hospital, New York. The authors gratefully acknowledge the grant made by the National Cancer Institute. Dr. Axel Trause is Diagnostic and Treatment, National Cancer Institute. Dr. Abels is Macy-Hershall Fellow.

TABLE I—EFFECT OF OPERATION UPON THE SERUM PROTEIN CONCENTRATION AND THE URINARY NITROGEN IN PATIENTS WITH GASTROINTESTINAL CANCER

Patient	Site of cancer	Operation	Preoperative serum protein concentration gm per cent	Maximum change of serum protein level during first 5 postoperative days—gm per cent	Average daily urinary nitrogen during first 5 postoperative days gm
R J	Esophagus	Thoracotomy	7.3	1.1	6.5
J M	Esophagus	Resection of terminal esophagus and cardiacotomy	6.0	-0.4	6.9
J M	Esophagus	Esophagectomy	6.0	-0.1	12.8
A A	Stomach	Gastrostomy	6.1	-0.1	8.8
F B	Stomach	Total gastrectomy	6.2	-0.7	9.8
S B	Stomach	Jejunostomy	5.5	0.0	8.0
A B	Stomach	Subtotal gastrectomy	6.6	-0.8	—
A D	Stomach	Exploratory laparotomy	6.6	-1.5	—
T C	Stomach	Jejunostomy	6.0	-0.9	—
C F	Stomach	Exploratory laparotomy	6.1	-0.9	—
S F	Stomach	Exploratory laparotomy	6.3	-0.3	11.0
T F	Stomach	Subtotal gastrectomy	7.1	-0.9	—
T G	Stomach	Subtotal gastrectomy	4.8	-0.5	—
H G	Stomach	Exploratory laparotomy	6.6	-1.0	8.5
P G	Stomach	Exploratory laparotomy	6.0	-0.7	9.2
A H	Stomach	Subtotal gastrectomy	7.2	-2.0	6.0
F G	Stomach	Subtotal gastrectomy	6.8	-0.5	—
S H	Stomach	Exploratory laparotomy	6.5	-0.1	—
W J	Stomach	Exploratory laparotomy	5.8	-0.5	6.7
N K	Stomach	Exploratory laparotomy	6.1	-0.5	7.5
F K	Stomach	Subtotal gastrectomy	7.1	-0.5	—
F K	Stomach	Gastroenterostomy	6.8	-1.0	—
I I	Stomach	Subtotal gastrectomy	5.0	-1.0	7.6
I M	Stomach	Exploratory thoracotomy	6.5	-0.7	16.8
M P	Stomach	Exploratory laparotomy	6.5	-0.7	12.6
J S	Stomach	Exploratory laparotomy	5.8	0.0	—
F P	Stomach	Gastrostomy	7.0	-0.7	—
R P	Stomach	Subtotal gastrectomy	7.0	-1.9	9.8
I R	Stomach	Subtotal gastrectomy	6.7	0.0	—
I R	Stomach	Total gastrectomy	7.1	0.0	—
D S	Stomach	Exploratory laparotomy	5.6	+0.5	6.7
J S	Stomach	Exploratory laparotomy	6.7	-0.5	—
D S	Stomach	Gastroenterostomy	6.5	-1.1	8.8
T V	Stomach	Exploratory laparotomy	6.0	-0.6	—
J T	Stomach	Subtotal gastrectomy	6.7	-1.5	6.2

TABLE I—EFFECT OF OPERATION UPON THE SERUM PROTEIN CONCENTRATION AND THE URINARY NITROGEN IN PATIENTS WITH GASTROINTESTINAL CANCER—CONCLUDED

Patient	Site of cancer	Operation	Preoperative serum protein concentration gm per cent	Maximum change of serum protein level during first 5 postoperative days—gm per cent	Average daily urinary nitrogen during first 5 postoperative days gm
R V	Stomach	Exploratory thoracotomy	6.8	-1.4	10.0
S W	Stomach	Exploratory laparotomy	4.6	+0.2	11.5
J Y	Stomach	Subtotal gastrectomy	6.9	-1.7	9.0
E Y	Stomach	Exploratory laparotomy	7.2	-0.5	—
M P	Duodenum (Ampulla of Vater)	Duodenectomy cholecystogastrostomy	6.5	-0.1	11.0
D R	Sigmoid	Drainage of a perisigmoid abscess	6.8	-0.5	8.0
J G	Rectum	Resection sigmoid	6.6	-0.7	6.0
E K	Rectum	Rectal resection	6.5	-0.5	8.8
J M	Rectum	Colectomy	7.5	-0.9	12.0
O R	Rectum	Rectal resection	7.3	-1.7	9.6
J S	Rectum	Rectal resection	6.8	-1.7	7.2
A A	Rectum	Rectal resection	6.7	-0.7	9.3
Average			6.31	—	8.96

The patients with gynecologic disease were hospitalized for from 1 to 4 days before operation. They received in that interval, and after operation, the same diets and amounts of fluids given to the patients with gastrointestinal disorders.

For 5 days after operation, the total urine was collected from most of the patients studied. These were obtained in 24 or 48 hour samples and during the periods of collection were kept at a hydrogen-ion concentration of about pH 1, with sulfuric acid, in order to prevent loss of ammonia.

**B Chemical** The concentrations of serum protein were determined by the method of Weech and associates. The urinary nitrogen was measured by the micro-Kjeldahl technique (9).

#### RESULTS

The preoperative concentrations of serum protein in the 47 patients with gastrointestinal cancer ranged from 4.6 to 7.5, and averaged 6.31 grams per cent (Table I). Of these



TABLE II.—EFFECT OF OPERATION UPON THE SERUM PROTEIN CONCENTRATION AND THE URINARY NITROGEN IN PATIENTS WITH NON-NEOPLASTIC DISEASE OF THE GASTRO-INTESTINAL TRACT

Patient	Diagnosis	Operation	Preoperative serum protein concentration gm. per cent.	Maximum change in serum protein concentration during postoperative 5 day period	Average daily urinary nitrogen excretion gm. per cent.
A D	Gastric ulcer	Subtotal gastrectomy			5
A G	Gastritis	Esophagoduodenostomy Removal of gastric tumor on side of liver		+6	
R G	Gastric ulcer	Subtotal gastrectomy		+6	5
J S	Gastric ulcer	Subtotal gastrectomy		+6	
H K.	Follicular gastritis	Subtotal gastrectomy		+6	
J O	Duodenal ulcer with obstructions	Subtotal gastrectomy		+6	10
O F	Gastritis	Esophagoduodenostomy		+6	8
T B	Gastric ulcer	Subtotal gastrectomy	5	+6	—
L P	Duodenal ulcer	Esophagoduodenostomy		+6	—
Average			54		37

Individuals, 23 were hypoproteinemc. During the first 5 postoperative days 41 developed hypoproteinemia. The serum protein concentrations fell in 40 of the 47 patients studied. The average decrease in these instances was 0.85 and the range of decrease from 0.1 to 2.0 grams per cent. In the remaining 7 patients the serum protein concentrations after operation either remained constant or increased from 0.2 to 0.5 gram per cent.

During this 5 day postoperative period, the total urine was collected from 30 of the 47 patients studied. The average daily urinary nitrogen excreted by each of these individuals ranged from 6.0 to 16.8 grams and the average of the group was 8.96 grams per day. These values of nitrogen excreted indicate that probably from 187 to 325 grams of protein (average 280.0 gms.) were catabolized by the patients with gastrointestinal cancer during

TABLE III.—EFFECT OF OPERATION UPON THE SERUM PROTEIN CONCENTRATION AND THE URINARY NITROGEN IN PATIENTS WITH GYNECOLOGICAL DISORDERS

Patient	Diagnosis	Operation	Preoperative serum protein concentration gm. per cent.	Maximum change in serum protein concentration during postoperative 5 day period	Average daily urinary nitrogen excretion gm. per cent.
M B	Fibrosarcoma	Supraventricular hysterectomy		+6	
E C.	Fibrosarcoma	Supraventricular hysterectomy	5	+6	
D H	Dysedema	Excision of cyst, appendectomy		+	10
L H	Fibrosarcoma	Supraventricular hysterectomy	5	+6	10.20
L M	Fibrosarcoma	Supraventricular hysterectomy		+6	5
A	Fibrosarcoma	Total hysterectomy, bilateral salpingectomy, oophorectomy		+6	10
M B	Fibrosarcoma	Bilateral oophorectomy		+6	17
B L	Carcinoma	Total hysterectomy, bilateral salpingectomy, oophorectomy			17
R L	Adenoma	Total hysterectomy, bilateral salpingectomy, oophorectomy		+6	10
Average			54		2.64

the first 5 days after operation. Since these individuals had received during the same period only from 35 to 150 grams of protein (average 85 gm.) they apparently sustained after operation a significant amount of tissue breakdown. No correlation could be obtained between the decreased concentration of serum protein and the amounts of nitrogen excreted by the patients of this group.

As control material for the observations just described similar studies were made in 2 other groups of patients. The first of these consisted of 9 patients with non-neoplastic disorders (Table II) who were submitted to surgical procedures similar to those to which were subjected the patients with gastrointes-



patients with gastrointestinal cancer becomes of considerable importance.

Although both the patients with gastrointestinal cancer and those of the 2 groups used as controls all excreted after operation comparably equal amounts of urinary nitrogen only the first group of individuals sustained considerable reductions of their serum protein levels. The explanation for this observation probably is that (a) the tissue protein stores of patients with cancer of the gastrointestinal tract are depleted and therefore cannot restore the serum protein concentrations to their preoperative levels, and (b) the ability of these individuals to fabricate serum protein is impaired.

It has been demonstrated that even before operation the patients with gastrointestinal cancer have hypoproteinemia. From evidence recently presented (11) a decreased concentration of serum protein in most instances has been found to be associated with depletion of tissue proteins. When hypoproteinemia exists only 3 per cent of ingested nitrogen is fabricated into plasma proteins and the remainder is used to replenish the tissue protein supply. Accordingly the hypoproteinemia observed before operation in the patients with gastrointestinal cancer in part may be due to the fact that the protein stores of these individuals already are too small to maintain a constant serum protein level under the stress resulting from surgical manipulation and inevitable postoperative period of nitrogen fast.

The impaired ability of patients with gastrointestinal cancer to fabricate serum albumin (3) probably contributes to their significant degree of postoperative hypoproteinemia. A previous study of this series (2) strongly suggested that this impaired ability is due to an hepatic dysfunction which like other hepatic functions (5) conceivably is further aggravated when the patients are subjected to surgery and manipulation of the liver.

## SUMMARY

1. Patients with gastrointestinal cancer frequently develop after operation a negative nitrogen balance. The extent of this negative balance is no greater than that often developed after operation by patients with non-neoplastic disease of the gastrointestinal tract or with gynecologic disorders who undergo intra abdominal operations.

2. Nevertheless, concentrations of protein in the serum of patients with gastrointestinal cancer fall after operation significantly more than do those of the patients with non-neoplastic gastrointestinal disorders or with gynecologic disease.

3. It is possible that the tissue protein stores of the patients with gastrointestinal cancer are considerably less than are those of the 2 control groups of patients studied.

## REFERENCES

1. ARTEL, J. M., ARTEL, J. C., PACK, C. T. and KENNEL, C. F. Metabolic studies in patients with cancer of the gastro-intestinal tract. XVI. The treatment of hypochloremia refractory to the administration of sodium chloride especially in patients with gastrointestinal cancer. To be published.
2. ARTEL, J. C., RAYNER, P. J., BREWSTER, G. I., PACK, C. T. and KENNEL, C. F. *Ann. Int. Med.* 44: 94, 1955.
3. ARTEL, J. M., RAYNER, P. E. and PACK, C. T. Metabolic studies in patients with cancer of the gastrointestinal tract. X. Abnormalities of protein metabolism in patients with gastric cancer. To be published.
4. BARNES, R. P., RAYNER, J. S. and FALGOUT, W. D. *Ann. J. Roent.* 93: 75, 66-70.
5. LIND, J. W., ANDERSON, D. W. and MORGAN, R. A. *Arch. Surg.* 92: 4, 183-90.
6. MADDEN, B. C. and WHITFIELD, C. H. *Physiol. Rev.* 30: 20, 94.
7. MADDEN, B. C. and JOY, J. *Surg.* 93: 46, 427-434.
8. MAYER, P. M., J. BARNETT, R. P. and RAYNER, J. S. *Surgery*, 93: 53-64.
9. PETERS, J. and J. SATTER, D. D. Quantitative Chemical Chemistry Vol. 1, p. 53. Baltimore: Williams & Wilkins, 1931.
10. READING, E., FLEISCHER, M. T. and P. NEER, L. M. *J. Am. Med. Ass.* 94: 8.
11. SCHUB, L. A., HOFFERT, A. and FLEMING, R. J. *Exp. Med.* 94: 75, 451-459.
12. WATSON, A. A., RAYNER, E. B. and GORTCHER, E. J. *Biol. Chem.* 95: 3, 67-74.

# TREATMENT OF GASTRIC ULCER

EDWARD S. JUDD, M.D., and JAMES T. PRIESTLEY, M.D., F.A.C.S.,  
Rochester, Minnesota

FOR many years the treatment of gastric ulcer has been the subject of considerable discussion and controversy.

Some physicians have been enthusiastic regarding medical treatment whereas certain surgeons have been equally in favor of surgical treatment in the large majority of cases. It would seem that this subject should be pretty well settled after the extensive clinical experience which has been amassed in the management of this condition. However, confusion still persists regarding the ideal choice of therapy in many of these cases.

The important questions which must be answered before definite opinions can be reached include (1) What is the percentage of error in the diagnosis of benign gastric ulcer when actually a small ulcerating carcinoma is present? (2) What is the percentage of cure of gastric ulcer treated medically? (3) What is the risk of operation for gastric ulcer? (4) What is the rate of ultimate cure of this lesion by surgical measures? Accurate answers to these questions should enable one to determine whether the risk of operation and chance of cure by surgical means are preferable to the chance of diagnostic error and likelihood of unsatisfactory results by medical measures. It is realized that generalizations often are misleading and unreliable for the individual patient, as obviously the choice of treatment must remain largely a matter to be decided for each individual patient, nevertheless it is helpful to know what the odds favor, so to speak. For this reason we have attempted to find answers to the questions listed.

## ACCURACY OF CLINICAL DIAGNOSIS OF GASTRIC ULCER

As everyone realizes, an entirely accurate differential diagnosis cannot always be made between benign and malignant gastric ulcer. To concede this point one need not have any

from the Division of Surgery, Mayo Clinic

firm conviction regarding the pathogenic relationship between these two entirely distinct entities, and this subject will not be discussed at this time. It is sufficient to admit that certain small ulcerating carcinomas of the stomach may present a clinical picture which cannot be distinguished from that which may be found in association with benign ulcer. The main differential points between benign and malignant gastric ulceration such as age of the patient, duration and type of symptoms, size and location of the lesion, achlorhydria or hyperchlorhydria, roentgenologic and gastroscopic appearance, and response to medical treatment may in certain cases all be misleading. Thus, examples can be cited from personal experience wherein all factors, such as youthful age of the patient, long history of typically ulcer-like character, small lesion situated on the lesser curvature associated with high values for gastric acids, a roentgenologic and gastroscopic diagnosis of benign ulcer and a favorable immediate response to medical management, favored the diagnosis of benign ulcer, but notwithstanding the patient subsequently was found to have an actual carcinoma. Likewise the reverse may be true, whereby the results of clinical investigation all suggest the malignant nature of the lesion and a benign ulcer is demonstrated histologically. It is true that such occurrences are not common but in a small percentage of cases the majority of factors may favor one diagnosis and yet the diagnosis based on these findings may be erroneous. The tragedy of permitting a small, readily resectable, malignant lesion of the stomach to progress to the stage of inoperability or to the time when prognosis is much less favorable even though resection can be accomplished, because of postponement of operation by the initial medical treatment need not be emphasized.

A few reported observations on the difficulty of distinguishing between benign gastric

ulcer and actual gastric carcinoma might be pertinent. For example approximately 7 per cent of patients who undergo resection for malignant growths of the stomach are less than 40 years of age (4). Eighty per cent of patients who have gastric resection for malignant tumors and who previously received medical treatment for presumed benign ulcer experienced temporary relief from this form of therapy. Approximately 1 of 5 patients who has gastric resection performed for cancer has normal or elevated values for gastric acids. Although 9 out of 10 benign gastric ulcers which are removed surgically are smaller than a quarter it has been noted that approximately one fifth of the carcinomatous lesions removed from the stomach have an area of ulceration 4 centimeters or less in diameter (2). Over a period of many years the diagnosis of gastric ulcer has been made by the roentgenologist in approximately 10 per cent of cases in which resection has been performed for actual carcinoma (4).

Thus it is emphasized again that there is no single clinical criterion which can make an accurate differential diagnosis between benign and malignant gastric ulcer. The only method of certain differentiation is prolonged observation under medical treatment. Such observation we believe should be carried on (intermittently following the first several months) for a period of at least several years. If the lesion disappears promptly and remains absent roentgenologically and gastroscopically for this period of time one would feel fairly confident that it is benign in nature. Of course should it prove to be malignant during this interval the optimal time for surgical treatment namely when the lesion was in an early stage of development, would have been lost.

What then in answer to the first question proposed is the actual error of diagnosis in benign ulcer? This may be approached in two ways, first the percentage of error found in cases in which patients are treated surgically and second the percentage of error found in cases in which patients are treated medically. A recent review revealed that carcinoma was found on exploration in 19 or 8 per cent of 237 cases in which a diagnosis of benign gastric ulcer was made and operation was per-

formed at the Mayo Clinic during 1930 and 1936. As a corollary in a series of 559 cases in which operation was performed for gastric carcinoma during this same period the diagnosis in the 19 cases mentioned here was gastric ulcer. In order to determine the results of the medical treatment of gastric ulcer of which more will be said later 146 patients whose condition was diagnosed as benign gastric ulcer between the years 1930 and 1937 and who were treated medically were traced to the present time. Of this group it is known that 14 patients, or 9.6 per cent subsequently were shown to have gastric carcinoma. This observation is supported by the findings of others, including Allen and Welch, who reported 277 cases in which the diagnosis of benign gastric ulcer was made. Thirty nine or 14 per cent of these patients later were known to have carcinoma. Some were treated medically and others surgically. Of the 175 patients in this group who were treated medically 13 or somewhat more than 7 per cent subsequently were found to have carcinoma. Considering the chance of diagnostic error based on clinical criteria from these various points of view it is evident that approximately once in 10 or 15 times the clinical diagnosis of benign gastric ulcer will be in error and in truth carcinoma will be present.

#### RESULTS OF MEDICAL TREATMENT OF GASTRIC ULCER

A recent study has been made concerning the second question namely what are the results of medical treatment of benign gastric ulcer? Cases in which the diagnosis of gastric ulcer was made in the Mayo Clinic during the years 1930 to 1937 as previously mentioned have been reviewed. More recent cases were not included in the study in order to have a follow-up period of at least 5 years. There were 146 cases in this group which filled the necessary requirements for the study namely a complete examination was performed the diagnosis of gastric ulcer was made medical treatment was instituted and knowledge of the present condition of the patient was obtained. There were numerous other cases, similar to these which were not included because of some slight suspicion of cancer the

fact that operation had been advised but not performed, and because information regarding the condition of the patient could not be obtained at this time. Of these 146 patients 68 were admitted to the clinic on one occasion only. In some instances this original admission constituted a prolonged period of observation, and in other cases it did not. Although, following their departure, fairly close contact was maintained with these patients through the physician at home and by other means, it might be said that this does not constitute adequate and proper treatment of the patient who has gastric ulcer. Therefore, this group of 68 patients was separated from the remaining group of 78 which was followed closely on repeated visits by roentgenologic or gastroscopic examination for an average of 2.9 years. In addition recent information regarding both groups of patients has been obtained by letter in most cases at an interval which varied from 5 to 12 years following the original admission. It was noted that the results were virtually the same in both groups of patients and for that reason the results obtained in the entire group will be considered. At first it might appear surprising that results were not definitely more favorable in the group which was kept under prolonged observation. On reflection, however, it is apparent that no amount of treatment could be accepted to influence the incidence of carcinoma in either group and most patients can follow the proper therapeutic medical regimen just as well following adequate instruction on an initial visit as after repeated visits, provided of course that adequate instruction is given the first time.

Of the 146 cases in which the diagnosis of benign gastric ulcer was made, medical treatment instituted, and the patient's progress during a period of 5 to 12 years ascertained, cure occurred in only 46.5 per cent (Table I). An additional 15.8 per cent of the patients had no symptoms if the medical regimen was followed constantly, 4.8 per cent were found to have gastric ulcer by roentgenologic diagnosis, 11 per cent were operated on because of failure of medical management and found to have gastric ulcer and 9.6 per cent (14 patients) presented definite evidence of gastric carcinoma. Of this group of 14 patients one-half

TABLE I—RESULTS OF MEDICAL TREATMENT OF GASTRIC ULCER

Type of Result	Cases	Per cent
Cure	68	46.5 ✓
Symptoms absent if medical regimen is followed	23	15.8
Gastric ulcer present roentgenologically	7	4.8
Operation for gastric ulcer	16	11.0 ✓
Definite evidence of carcinoma developed	14	9.6 ✓
Death from hemorrhage	1	0.7
Deaths from unrelated causes	17	11.6
Total	146	100

(7 patients) died of metastatic carcinoma and the remainder were explored surgically, however, in only 3 cases could the gastric cancer be removed. Eleven and six-tenths per cent of the entire group of 146 patients died of apparently unrelated causes and 0.7 per cent (1 patient) died of gastric hemorrhage.

Analysis of these results indicates that the medical treatment of presumed benign gastric ulcer leaves considerable to be desired. With cure accomplished in somewhat less than 50 per cent of cases and with approximately 10 per cent of patients subsequently manifesting frank carcinoma of the stomach, one could hardly call the results eminently satisfactory. In addition, 11 per cent of the patients required operation subsequently for benign gastric ulcer because of failure of medical management. One need operate on only a few penetrating gastric ulcers which have eroded completely through the wall of the stomach and have a crater, the base of which is formed perhaps by the pancreas, to appreciate the difficulties inherent in effecting complete healing of the lesion by medical measures. In addition, the marked degree of gastritis and inflammatory activity of a benign gastric ulcer so often seen at the operating table following intensive medical treatment for several weeks in the hospital prior to operation serve to emphasize the ineffectiveness of medical management in many of these cases.

#### RISK OF SURGICAL TREATMENT OF GASTRIC ULCER

In contrast with results obtained by the medical treatment of gastric ulcer, what may be expected from the surgical treatment of these patients? The first question to consider

in this regard is the risk of operation. This, of course will vary with the condition of the patient, experience of the surgeon, type of operation performed, and preoperative and postoperative care. It is obvious that no definite figure can ever be established in this connection which will be universally applicable for all patients and all surgeons. About all that can be determined in this regard is for an individual surgeon or group of surgeons to record personal experience in cases of this type. During the past 5 years at the Mayo Clinic the risk of gastric resection performed for gastric ulcer in 400 cases has been 3.5 per cent. During this same time the risk of local excision and gastroenterostomy for gastric ulcer has been 3.3 per cent. These mortality figures include all patients who died in the hospital following operation.

#### ULTIMATE RESULTS OF SURGICAL TREATMENT

What then may one anticipate regarding ultimate cure of those patients who have gastric resection performed for benign gastric ulcer and survive the operation? In our experience resection of the stomach for gastric ulcer is followed by some of the most satisfactory results that are obtained in the surgical treatment of any gastric or duodenal lesions. Walters and Clagett (3) in 1940 reported on 272 cases of gastric ulcer treated surgically. Follow-up studies over a period of 1 to 5 years were obtained in 162 cases. There was no known incidence of the development of gastrojejunal ulcer and only one patient in the entire group classified his result as entirely unsatisfactory. Of 29 patients followed on whom local excision combined with gastroenterostomy was performed 27 had an entirely satisfactory result and 2 had mild distress at times. Of 85 patients on whom a Polya type of resection was carried out 80 had an entirely satisfactory result and 5 were in good health but had occasional slight distress. Information in some of these cases was obtained by questionnaire which may be considered unreliable; however it is seldom that a patient will write that he is well unless he actually feels well. The length of follow-up period may be a little short for an accurate analysis of the true ultimate results and yet

it coincides quite closely with our experience. Other procedures such as local excision alone, sleeve resection or gastroenterostomy alone are followed by somewhat less satisfactory results.

#### CHOICE OF OPERATION FOR GASTRIC ULCER

In former years local excision of a gastric ulcer combined with gastroenterostomy was considered to be the treatment of choice in many cases. At the present time we seldom employ this form of treatment for several reasons. In the first place if local excision of the ulcer is performed in a certain number of cases, the pathologist may subsequently report that the lesion actually is malignant in which case an entirely inadequate removal of the involved tissue has been performed and further operation is advisable in most cases. In addition it has been found during recent years that gastric resection can be performed for gastric ulcer with virtually the same mortality rate associated with local excision and gastroenterostomy. Formerly it was thought that certain gastric ulcers were inaccessible for resection but we know now that virtually every gastric ulcer can be removed by resection with utilization of various modifications of the P. Iva type of operation, notably the Hofmeister type. By way of digression it might be mentioned that the presumed inaccessibility of certain gastric ulcers formerly was used as an argument in favor of medical management of certain high-living lesions. This argument is no longer valid. Gastroenterostomy alone does not constitute adequate treatment for the patient with gastric ulcer as in 8 of the 46 cases of gastric ulcer previously mentioned, this operation had been performed previously (in 6 cases for duodenal ulcer and in 2 cases for gastric ulcer).

The surgical treatment of choice in most cases of gastric ulcer we think is gastric resection. For the lesion situated in the distal third of the stomach, a Billroth I type of operation can be employed with satisfaction in some cases. In general the posterior Polya operation is the one which we employ most frequently. When dealing with an ulcer situated high on the lesser curvature of the stomach, the Hofmeister modification of the

posterior Pólya operation often is most satisfactory. Occasionally if the lesion is especially high, an anterior type of anastomosis without enteroanastomosis is employed. This type of operation, however, is used only infrequently. Modifications of this procedure may be employed for an ulcer situated in the cardia on the anterior or posterior walls of the stomach.

#### OBSERVATION

On the basis of our experience we are inclined to favor the surgical treatment of gastric ulcer in an increasing number of cases. Thus, the preoperative diagnostic error in cases of gastric ulcer of approximately 10 per cent and the late results of medical treatment with somewhat less than half of the patients being completely relieved does not make a very good record for medical treatment. In contrast the low operative risk of gastric ulcer (2.5 per cent for resection) and the satisfactory end-results in the large majority of cases certainly favor surgical treatment in these cases. This is especially true when dealing with the perforating lesions which we believe are always surgical if the patient's general condition permits. We do not mean to imply that all cases of simple, superficial gastric ulceration, perhaps associated with an exacerbation of gastritis should be treated surgically. Lesions of this type generally respond readily to medical management and do not carry the threat of unrecognized malignancy. It is realized that conclusions based on a statistical study of this type may be misleading. On the other hand, observations of the various cases reported form the basis on which one may logically establish clinical judgments. It is our opinion that the choice of treatment for the patient with gastric ulcer really does not lie

between medical and surgical but rather between immediate surgical treatment and a trial of medical management under close observation followed by surgical treatment if prompt and permanent healing of the ulcer does not occur. By adhering to this type of medical management the unfortunate development of a large and inoperable carcinoma prior to its recognition may be obviated in most cases. In reaching the decision regarding the choice of medical or surgical treatment in a given case, it is well to keep in mind the relative risk of each form of treatment as well as the chance of cure which either medical or surgical treatment may afford.

#### SUMMARY

1 The error in the preoperative diagnosis of gastric ulcer in differentiation from gastric cancer is approximately 10 per cent.

2 Only approximately half of the patients who are treated medically for gastric ulcer have a result which they consider entirely satisfactory.

3 Approximately 10 per cent of patients treated medically for gastric ulcer subsequently prove to have carcinoma.

4 The risk of gastric resection for gastric ulcer in our experience is 2.5 per cent.

5 The results of the surgical treatment of gastric ulcer are entirely satisfactory in the majority of cases.

#### REFERENCES

- 1 ALLEN, A. W., and WELCH, C. E. *Ann Surg*, 1941, 114, 498-509.
- 2 ALVAREZ, W. C., and McCARTY, W. C. *J Am M Ass* 1928, 91, 226-231.
- 3 WALTERS, WALTERMAN, and CLAGETT, O. T. *Surg Gyn Obst*, 1940, 71, 75-79.
- 4 WALTERS, WALTERMAN, GRAY, H. K., and PRIESTLEY, J. T. *J Am M Ass*, 1941, 117, 1675-1681.



# RUPTURE OF THE UTERUS

## An Analysis of 30 Maternal Deaths

CHARLES A. GORDON M.D. F.A.C.S. and ALEXANDER H. ROSENTHAL, M.D. F.A.C.S.  
Brooklyn, New York

**R**UPTURE of the uterus is commonly stated to be a grave complication of pregnancy and labor yet it is generally thought to occur infrequently and its importance as a considerable increment of our puerperal mortality is not generally appreciated. The frequency of its occurrence is actually unknown figures on its incidence varying widely from 1 in 95 (13) deliveries to 1 in 6000. A growing appreciation of the great importance of the rôle of hemorrhage in maternal deaths, and reports of several large series of rupture of the uterus (1-3-6-13) during the last 5 years show increasing interest.

In any area the frequency of traumatic rupture at least, will depend upon the quality of obstetric care. In hospital practice its incidence will vary with chance factors. Old figures are largely voided by the increasing frequency of cesarean section. Lynch has reported 33 cases during a 20 year period at the Boston City Hospital and Sheldon found the same number of cases at the Boston Lying In Hospital from 1916 to 1938 an incidence of 1 in every 1105 deliveries. Reese and Linn, reporting 34 cases from the records of the University and Baltimore City Hospitals, found an incidence of 1 in 1516 cases. Dugger for the Committee on Maternal Welfare of the Philadelphia County Medical Society analyzed 105 cases, all the cases known to have occurred in Philadelphia during the 10 year period 1931 to 1941 an incidence of 1 in every 3,029 births. There were 65 deaths in this series, a mortality of 62 per cent which contributed 6.6 per cent to the puerperal mortality rate, if ectopic pregnancy and abortion were excluded. Bingham reporting on maternal mortality for 1940 in the State of New Jersey says that rupture of the uterus was a frequent cause of death, one half of these cases resulting from version. Titus

found 7 cases diagnosed as rupture of the uterus in 276 cases of puerperal death in Massachusetts in 1938 yet he felt sure that in other cases in which death was attributed to shock, rupture of the uterus was the actual cause. In Rhode Island (12) in 1940, there were but 25 puerperal deaths, yet in 3 cases, or 12 per cent of that state's enviably low mortality rate death was due to rupture of the uterus.

Siegel (7) analyzing the puerperal mortality of the City of Buffalo for 1935-1940 reported 18 deaths due to uterine rupture accounting for 6 per cent of the total number of 313 puerperal deaths or 8 per cent of deaths when ectopic pregnancy and abortion are excluded. Nearly one half of these deaths occurred during version and extraction. It appears, however that there were 32 deaths in Buffalo due to version in 21 of these death occurred on the first day, yet only 7 were known to have a ruptured uterus. The opinion of the Maternal Mortality Committee in Buffalo (8) was that the number of deaths attributed to this cause would have been very much higher if more cases had come to autopsy.

When the Children's Bureau (10) in 1927-1928 studied 7,380 maternal deaths in 15 states but 91 cases were found in which rupture of the uterus was diagnosed by the attending physician or at autopsy. However the obstetric advisory committee believed that the history clearly pointed to rupture in 68 cases, and made such a diagnosis probable in 109 other cases, a total of 268 cases. These deaths accounted for 3.3 per cent of the total rate or 5.4 per cent if ectopic gestation and abortion were excluded. The proportion of maternal deaths that were associated with ectopic gestation as either primary or secondary was 4 per cent varying from 1 to 7 per cent in the several states.

In 1940, in the entire United States (11), ectopic gestation accounted for 4.4 per cent of the total number of puerperal deaths, or 5.5 per cent exclusive of abortion. It is probable that rupture of the uterus is an even more important cause of maternal death, for 23 per cent (2,058) of all the puerperal deaths (8,876) were caused by hemorrhage, trauma, and shock, yet placenta previa and separation of the normally implanted placenta accounted for only hardly more than one-fifth of them (448).

In Brooklyn, City of New York, the Committee on Maternal Welfare of the Medical Society of the County of Kings, after study of 660 puerperal deaths recorded during the period January, 1937, to September, 1942, found that at least 30 women died from rupture of the uterus, or 5.4 per cent of the total, if deaths due to ectopic gestation and abortion were excluded. During this same period, ectopic gestation accounted for 5.7 per cent of the deaths, excluding abortions.

It seems clear, then, that in many communities rupture of the uterus exceeds, or at least equals, ectopic pregnancy as a cause for maternal mortality. The comparison may be carried further, for, like ectopic pregnancy, rupture of the uterus must be thought of in a given case if the diagnosis is to be made more frequently. In our own experience failure to consider rupture of the uterus as a cause for such single or combined symptoms as loss of the fetal heart, cessation of contractions, and shock during labor, or shock after operative vaginal delivery when external hemorrhage has been insufficient to account for it, has often resulted in failure of diagnosis and death.

In 11 of these cases of death from rupture of the uterus the diagnosis was not made by the physician until autopsy findings were reported. The committee believes that the actual number of deaths was larger than the number reported, for there were other cases in which the diagnosis was probable and have not been included in these figures.

It is not possible to state the true incidence of rupture of the uterus in Brooklyn since the files of the committee contain information only on those in whom operation or autopsy showed death from this cause. Fairly good

abstracts of 30 such case records are available. In every case the diagnosis was proved by operation or autopsy or exploration of the uterus. Not all the data we should like to have can be found in these records, and the description of symptoms and signs associated with rupture was often meager, yet information as to the time of diagnosis and the nature of treatment was definite in every case.

#### CLINICAL DATA

*Age, color, and parity.* In 15, or half the patients, rupture took place between the ages of 35 and 45 years. There were 5 patients in the age group 20 to 30 years, 10 patients in the 30 to 35 years group, 11 patients were between the age limits of 35 to 40 years, and 4 patients between the ages of 40 to 45 years. In 2 cases color was not recorded, 23 were white and 5 colored. There were only 3 primiparae and they were in the age group 20 to 35 years.

*Duration of labor.* In only 2 cases did rupture occur before the onset of labor. In one of these, a primipara, rupture of a myomectomy scar occurred in the seventh month of pregnancy. At operation, 1 hour later, a living fetus was extracted by enlarging the tear in the uterus, which was then sutured. She vomited repeatedly during the one-half hour required for induction of ether anesthesia, and died of bronchopneumonia. The other patient was a young colored multipara in the sixth month of pregnancy who died of peritonitis following operation at which a rent was found in the lower segment of the uterus anteriorly. The cause of rupture was unknown, though it was possibly due to instrumental perforation.

The duration of labor in the other 28 cases is shown in Table I.

TABLE I—HOURS IN LABOR

No. of hours	Spontaneous	Traumatic	Total
Less than 6	4	1	5
6 to 12	7	2	9
12 to 24	1	3	4
24 to 36		3	3
More than 36		*5	5
Unstated		2	2
	12	16	28

All patients in the table were multiparae except 2 in this group.

*Etiology.* Spontaneous rupture occurred in 13 cases. All but 2 took place during labor. In

TABLE II—SPONTANEOUS RUPTURE

No.	Age	Fetus	Hrs. in labor	Stage of labor	Site of rupture		Causal factors
					Lower	Upper	
1	4				X		Flaccid, obesity postnatal abdomen
40	14	18			X		Obesity postnatal abdomen
36	2				X		Hydrocephalus
30	1				X		Frontal, bulky, indurated abdomen
36	1					X	Previous section
6	33	8			X	X	Contraction of cervix
7	37	2	60		X	X	Cervical scar
11	2	1			X		Cervical scar

3 cases no cause could be assigned, and in the other 8 cases the causes were varied (Table II)

Cases 6, 7 and 8 in Table II are of special interest. In all there were probably extensive cervical scarring. In Case 6 there had been done a previous cauterization of the cervix. In Case 7 the previous history included a difficult forceps delivery with cervical laceration and at operation the tear in the lower uterine segment was directly continuous with a complete lateral tear in the cervix. Case 8 was similar in that the previous history included a version and extraction through an incompletely dilated cervix and we can assume the occurrence of laceration and subsequent scarring. These 3 cases clearly show the rôle of cervical scarring in the etiology of spontaneous rupture. It may also explain certain cases of spontaneous rupture in apparently normal uteri in the *gravidis multipara* during labor. Previous theories have referred principally to myometrial pathology rather than to extension of cervical laceration into the lower uterine segment.

**Traumatic.** In this group were 17 patients rupture in 1 case occurring during pregnancy. Pituitrin was the cause in 1 case. It may have been administered in other cases, but, if so it was not reported. In the remaining 15 cases version accounted for 7, in 3 of which forceps had failed. Four were due to forceps, 2 followed mutilating operations, 1 the Pinard

TABLE III—TRAUMATIC RUPTURE OF THE UTERUS—VERSION

Age	Fetus	Hours at labor	Stage	Previous procedure	Complication
31 <sup>0</sup>	8	—			Placenta previa
38		2			Transverse
31 <sup>0</sup>		30		Incisions in cervix	Transverse
37 <sup>0</sup>	1	24		Failed forceps	
		37		Failed forceps	Disproportion
26 <sup>0</sup>		57		Failed forceps	Disproportion
23		75		Manual rotation	Disproportion

\*Version followed by extraction.

maneuver and 1 was due to strong and prolonged fundal pressure.

Internal version was the principal cause of traumatic rupture. Table III shows that in 5 of the cases version was performed after 30 to 58 hours of labor a definite contraindication to this procedure because of marked thinning out of the lower uterine segment. Other hazardous procedures, such as prompt extraction following version for placenta previa, were also reported.

**Signs and symptoms.** In the 2 cases of spontaneous rupture which occurred before labor began severe abdominal pain followed without bleeding or shock. In the other 11 cases of spontaneous rupture shock was notable occurring in 9 cases. Vaginal bleeding was profuse in 2 cases slight in 7 cases, not mentioned in 1 case and in 1 case there was none at all. Abdominal pain was severe in but 5 cases. In 6 cases labor ceased. In only 3 cases were fetal parts recorded as easily felt beneath the abdominal wall.

The clinical picture of traumatic rupture was one of shock, with or without increased vaginal bleeding. In 11 cases shock was profound and hemorrhage was profuse in 6 cases.

**Site of rupture.** In 26 cases rupture was complete and in 4 incomplete. Except in 2 cases in which rupture followed myomectomy and previous cesarean section the lower segment was involved in every case. In 4 cases involving both upper and lower segments, was due to previous suspension of the uterus for retroversion and cauterization of the cervix, 1 was caused by pituitrin, 1 was of

unknown origin occurring in a multipara, aged 38 years, after 8 hours of labor, and one began at an old cervical scar and extended superiorly.

In 6 cases of rupture in the lower segment, its exact location was not stated. Lateral longitudinal rupture right or left, was the common lesion, with 15 cases in this group. Hematoma of the broad ligament was frequently observed. Transverse rupture of the anterior lower segment was next in frequency, a total of 6 cases, with 2 cases of spontaneous rupture during labor occurring in this group. Posterior rupture of the lower segment was noted in 3 cases, in 2 of these cases forceps had failed of delivery, and in the other, 2 semilunar transverse tears resulted from the Scanzoni maneuver.

**Diagnosis** The diagnosis was made before death in 19 cases, yet in 7 cases more than 2 hours had elapsed, and in 1 case not until 7 days after rupture had occurred was the diagnosis made. In 11 cases the diagnosis was made only at autopsy. Thus in only 12, or 40 per cent of the cases, was the diagnosis made within a time interval in which there is reasonable opportunity for successful treatment.

In the spontaneous rupture group, the diagnosis was not made in only 3 cases. In 1 case, because of precordial pain and dyspnea, shock was thought to be due to coronary thrombosis, in another, rupture of a cesarean section scar was mistaken for ablatio placentae, and the third case occurred in a quattuordecipara, 40 years of age.

In rupture due to trauma, however, the diagnosis was correct in but 9 of the 17 cases. Hemorrhage and shock were commonly attributed to the operative procedure, not to rupture of the uterus. The lapse of time before diagnosis was made is shown in Table IV.

**Treatment and causes of death** In 13 cases operation was not performed, principally because of failure of diagnosis, for in 11 cases, it will be recalled, the diagnosis was first made at autopsy. Eleven of these women died of hemorrhage and shock within a few hours, while 2 died of peritonitis.

Supravaginal hysterectomy was performed in 16 cases, and in 1 case the laceration was sutured. In 9 cases hemorrhage and shock

TABLE IV — TIME INTERVAL IN DIAGNOSIS

Type of Rupture	Within 2 hours	More than 2 hours	Not until autopsy
Spontaneous	7	3	3
Traumatic	5	4	8
Total	12	7	11

caused death shortly after operation, in 4 cases death was due to peritonitis, and in 3 cases to bronchopneumonia.

In the entire number of 30 cases death was due to hemorrhage and shock in 20 cases, peritonitis in 6 cases, bronchopneumonia in 3 cases, and anuria in 1 case.

Of the 30 babies 3 survived, a fetal mortality of 90 per cent. Two women died who were undelivered.

Adequate transfusions of blood were administered in but 3 cases, 11 women received moderate amounts of blood, 5 received totally inadequate amounts, and 11 were given no blood at all. Undue confidence was had in crystalloid solutions, and many varieties of cardiac stimulants were administered. Blood plasma or serum were not used in any case, yet it is admitted that the large majority of these deaths took place before the value of these blood substitutes had been well recognized.

#### SUMMARY

The importance of rupture of the uterus as a factor contributing at least 6 per cent to the maternal death rate is shown. It probably is a more common cause of death than ectopic gestation. There is very little doubt that rates are higher than commonly reported, for failure of diagnosis is common.

In an analysis of 30 puerperal deaths occurring in Brooklyn during a 6 year period, the rôle of age and multiparity is shown and the causes of rupture and the data associated with delivery are indicated. Rupture was spontaneous in 13 cases. In the group of 17 traumatic cases, 7 were due to version in the face of well accepted contraindications.

With the exception of 2 cases in which rupture occurred at the site of a previous cesarean section or myomectomy scar, it was the lower segment which was involved in every case.

The diagnosis was late in the majority of cases being made within 2 hours in only 12 or 40 per cent of the cases. In 12 cases the diagnosis was first made at autopsy.

In the traumatic group hemorrhage and shock were commonly attributed to the operative procedure and not to rupture of the uterus. In 3 cases in which the uterus was explored the rent in the uterine wall was not discovered.

Inadequate blood transfusions, or none at all were administered to the majority of patients. Other intravenous therapy and various cardio-respiratory stimulants were relied upon for treatment of shock.

## REFERENCES

- BRADSHAW, W. D. and VANDER, G. A. *Clinics*, 941.
2. BINGHAM, A. W. *J. M. Soc. N. Jersey* 94 30 22.
3. DOOGRE, J. H. *Pennsylvania M. J.* 942 45 427.
4. LANCE, F. J. *N. England J. M.* 939 51 847.
5. REEF, J. M., and LUCE, R. F. *West Virginia M. J.* 94 27 202.
6. KILLDON, C. P. Discussion of paper by Lynch, Loc. cit.
7. SIGGEL, L. A. *N. York State J. M.* 94 42 47.
8. IDEM. Personal communication, Dec. 9, 94.
9. TERRY, R. S. *N. England J. M.* 939 845.
10. U. S. Department of Labor. *Children's Bureau* Publication No. 223.
11. *PEDIATRIC J. Child*, 942, 6 05.
12. WALKER, J. G. *Rhode Island M. J.* 93 243 30.
13. WHITTAKER, F. E., and F. NO, L. V. *Arch. Surg.* 942 45 3.
14. WHITE, R. E. *J. M. Soc. N. Jersey* 94 30 445.

# HEPARIN TOLERANCE

## A Test of the Clotting Mechanism

GEZA de TAKATIS, M D, M S, F A C S, Chicago, Illinois

**D**URING the use of heparin in surgical patients one encounters a great variability of response in different individuals or even in the same individual under different circumstances. Thus some patients seem to react promptly and intensely, whereas, others require a great deal of heparin to obtain a sufficient prolongation of the clotting time. It would take several days to readjust the dosage to the patient's requirements and much important time would be lost whether the continuous or the intermittent type of intravenous administration were used. Also hematomas or severe hemorrhages were encountered after operation in patients who had received the customary, moderate doses of heparin.

Later, it became obvious that even the same patient would show a variable response under different circumstances. A simple test for heparin sensitivity was devised, simple enough so that it could be run in any hospital or home, whenever the administration of heparin seemed advisable. For the experimental and clinical studies on heparin, one can refer to the work of Best, Murray and his coworkers (11) and those of Crafoord and Jorpes. Monographs and reviews have recently summarized the previous literature (4, 7, 9).

In this communication I wish to report my preliminary observations made with 328 tests on 114 patients. The test provides an interesting insight into factors influencing the clotting mechanism and thus opens an avenue for further investigation.

### THE METHOD

Ten milligrams (1 cc) of purified heparin are injected intravenously. A hypodermic

From the Department of Clinical Research and the Medical School of the University of Chicago, Chicago, Illinois. This work was supported by the National Cancer Institute, U. S. Department of Health, Education and Welfare. The author is indebted to Mr. Vincent McGee for his assistance in the preparation of the manuscript.

syringe and needle are used for the purpose. Coagulation time is determined before and 10, 20, 30, and 40 minutes after the injection. The capillary tube is used for the determination of coagulation time. The finger tip is punctured with a standard automatic lance. The first drop of blood is gently wiped off and the second drop is taken up by the capillary tube. The tubes are drawn out to a length of 15 to 20 centimeters (5 to 8 inches), their diameter is 1 millimeter. They should be chemically clean and dry. During the test the tube is held in the palm of the hand, thus providing a thermostatic control. The tube is broken every 30 seconds (or more often if desired), and the appearance of the first thread of fibrin is taken as an end-point, measured from the time the second drop of blood appeared.

This method can be taught to and used by student nurses, and occasionally by patients who administer oral anticoagulants to themselves. The percentage of errors occurring from the mixture of the blood with tissue juice is small. The method is not such an accurate estimate of the pure coagulation time as the Lee and White procedure, which is preferred by most research workers. However the determination of venous blood *in vitro* as practiced by Lee and White, fails to measure two important factors in spontaneous hemostasis namely, the admixture of thromboplastin at the time of injury and the capillary contractility. The former is included in the capillary method the latter is measured if desired by the equally simple bleeding time.

A normal response was plotted from an average of 50 curves (Fig. 1). Arbitrarily if the coagulation time did not rise above 4 minutes at 10 minutes after the injection, the patient was labeled as having a subnormal or delayed response. In some cases the curve remained absolutely flat the coagulation time having been entirely uninfluenced by the small amount of heparin. On the other hand hyper

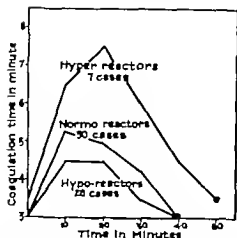


Fig. The response of the first 85 patients after the intravenous administration of 500 mg of heparin. Arbitrarily they were labeled as hyperreactors, if the coagulation time did not rise above 4½ minutes after the injection of heparin. The term hyperreactor is used for patients whose coagulation time rose 1 or above 7½ minutes after the injection of heparin.

reactors were also encountered showing phenomena of sensitization such as flushing of the face difficulty in breathing sweating and faintness. In this group 8 such cases were encountered but I have seen several such reactions before this study was undertaken. The heparin curves in the same individual are remarkably constant. They were determined for 17 consecutive days without notable change (Table I)

#### THE HYPOREACTOR GROUP

Of the 87 patients studied 36 were placed in the group of hyporeactors some of them only temporarily. The comparatively high incidence of patients with poor response to heparin is explained by our interest in just such a group. They were subdivided into patients in the postoperative state patients with cardiovascular accidents and patients suffering from Buerger's disease.

*A. The postoperative state.* If one uses the diagram of Schmidt Fuld Moravitz for the explanation of the clotting mechanism, one would expect an increased need for heparin in the early days following operation when thrombokinase is liberated from the tissues and when platelets disintegrate (Fig 2) Else

TABLE I.—DAILY HEPARIN CURVES FOR 17 DAYS

Date	Before Heparin Minutes	After Heparin Minutes			
		Minutes			
		30	45	20	45
August 24					
25	5			5	5
26			5		
27		5			
28	6				
29	6				5
30				5	
31			5		
September 1	6		5	5	5
			5		5
	6				
5				6.6	
	5	6		5	
				5	
	6				
	5.5		5	5	5.5

Oval L., 9 years old. Compound fracture of right leg and thigh suffered 2 weeks previous to tests

where (5) I have summarized the changes in the blood reported after operations. There is an initial fall and secondary rise in platelets, an increase in fibrinogen, a shift or reversal of the albumin-globulin ratio in favor of the globulins and an increase in blood viscosity. All of these factors favor the agglutination of platelets, which normally possess a marked negative potential and tend to repel each other.

The coagulation of the blood is favored by the postoperative leucocytosis and the disintegration of platelets, both of which liberate thrombokinase. Dehydration and loss of plasma occurring in burns, shock, and intestinal obstruction also shorten coagulation time.

Thus, the agglutination of platelets seems largely responsible for the initial thrombus, whereas, the increased coagulability of the blood hastens the superimposed spreading red thrombi in the stagnating or retarded blood stream surrounding the agglutination-thrombus. In the postoperative state then, a

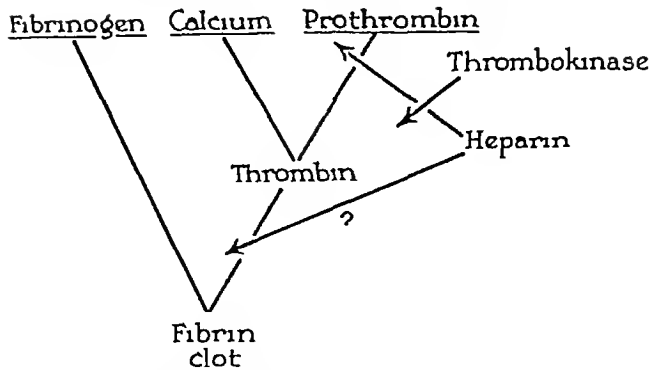


Fig 2 The theory of clotting (Howell) The three fundamental factors, fibrinogen, calcium and prothrombin are underlined. In the case of injury to tissues or after disintegration of platelets, thrombokinase (cephalin) is released and counteracts heparin so that prothrombin is free to join with calcium to form thrombin, which in turn unites with fibrinogen to form fibrin.

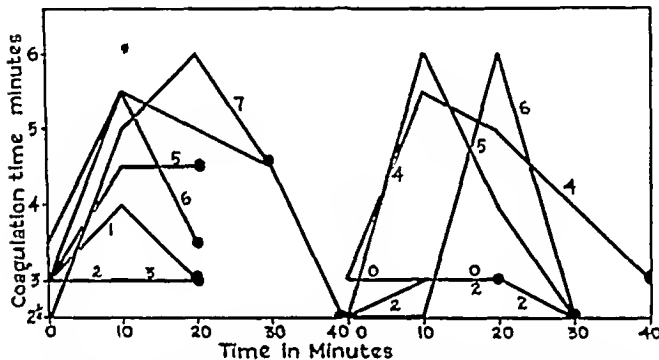


Fig 3 Serial heparin curves of 2 patients, both of whom show marked heparin resistance after operation. In the case of H.W. (ruptured appendix, diffuse peritonitis), the curves, at left, are completely flat on the 2d and 3d days, whereas in the case of M.H. (congenital hypoplastic kidney, hypertension, nephrectomy), at right, the curve is absolutely flat on the day of operation and very flat on the 2d day. After the 4th day, both patients exhibited a normal response. Figures on curves indicate day after operation.

combination of increased agglutination of platelets and an accelerated coagulability are at work.

Recently Shapiro, Sherwin, and Gordimer confirmed the initial fall and subsequent rise of platelets following operations and also the initial decrease and secondary increase in prothrombin levels. In 14 out of 23 surgical cases, the prothrombin level was found to increase usually concomitantly with the thrombocytosis occurring on the 6th to 10th day following operation.

The heparin curves determined daily after operations show a marked flattening, some-

times a complete resistance to heparin. This phase usually ends on the 4th day, corresponding to the increase in platelets; there is an increase in prothrombin activity (14). Two such serial determinations are shown in Figure 3. In the case of H.W. the response to heparin was diminished on the 1st day after operation, completely absent on the 2d and 3d days, improved on the 5th, normal on the 6th and 7th days. In the case of M.H. the response to heparin was absent on the day of operation, very slight on the 2d day and normal after the 4th day. If the patients are hyperreactors to start with, the decreased



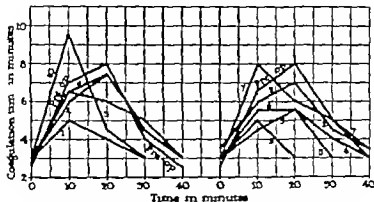


Fig. 4. Both of these patients are hyperreactors before operation. As result, their postoperative resistance is not as marked as that shown in the previous graph. Nevertheless, on the 1st and 3d days, respectively the response to heparin is diminished. At left, H. F. hypertension, sympathectomy. At right, M. S. uterine fibroids, abdominal hysterectomy.

response to heparin is not as marked and only very temporary (Fig. 4). It is still evident, however, on the 1st postoperative day of H. F. and the 3d and 5th days of M. S. Conversely in the case of H. Z., who consistently showed a diminished reaction to heparin, the postoperative period was characterized by a complete lack of reactivity on the 3d and 6th days; the only fair response on the 8th and 9th days. The last curve obtained on the 11th postoperative day with a peak of  $4\frac{1}{2}$  minutes at 10 minutes, places this patient in the hypo-reactor group (Fig. 5). Minor surgical operations, however, do not influence the heparin curve (Fig. 7).

**B Cardiovascular accidents.** Patients with coronary thrombosis, cerebral thrombosis, arterial embolism and venous thrombosis,

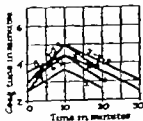


Fig. 5. This patient belongs to the group of hypo-reactors and his curves are flattened throughout the post-operative period. Such patients' left external arterial and venous thrombosis are frequently affected by spreading thrombosis or embolism following operation. H. Z. massive gangrene of foot, amputation.

exclusive of Buerger's disease have been grouped under this heading. Eighteen patients are available for study, all showing flat curves. Only patients whose vascular occlusion occurred within a few days of the determination of their heparin sensitivity are included. As a control, we have a group of patients with identical vascular involvement but in whom the thrombotic episode has occurred weeks or months previous to the study of their response to heparin. These curves fall within normal limits. A few of the illustrative curves are charted in Figure 6.

Patient 1, R. S., has been under our observation for several years with rheumatic heart disease, auricular fibrillation, and multiple emboli to extremities and brain. This curve was obtained during one of her numerous admissions, 4 days after a popliteal embolus. Patient 2, E. B., has had coronary and peripheral arterial thromboses on an arteriosclerotic basis. Patient 3, M. R., had a low grade thrombophlebitis in large saphenous varicosities. Patient 4, M. M., has had rheumatic heart disease, auricular fibrillation and five peripheral emboli with three embolectomies. This curve was obtained within 24 hours of the fourth femoral embolus. Patient 5, P. S., had a cerebral thrombosis 48 hours prior to the curve shown. Cases 3, 4, and 5 showed no response to heparin, whereas, cases 1 and 2 showed some elevation of the coagulation

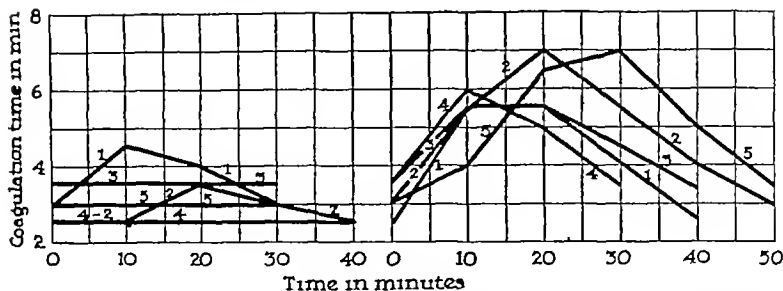


Fig 6 a, On the left are shown the curves of 5 patients who have suffered an acute vascular occlusion within a few days prior to these determinations. As a control, b, on the right are the curves of patients, in whom the vascular accident had occurred several weeks or months previously.

time, but the response was below the normal average. As a control Figure 6, b shows the curves of five patients equally afflicted with vascular thromboses but not in a stage of an acute occlusive episode. Patient 1 is F M with chronic coronary sclerosis. Patient 2 is S B, who has had coronary arterial disease for years with angina on effort, but no recent vascular occlusion. Patient 3, E K A, had neurocirculatory asthenia. Patient 4 is A P, who suffered a coronary occlusion  $3\frac{1}{2}$  years previously but has had no other episode. Patient 5, M N, had a chronic thrombophlebitic induration due to an old iliofemoral thrombosis. Her curve was somewhat atypical as it rose slowly, reached the peak of 7 minutes as late as 30 minutes, and did not return to normal for 50 minutes. It is not a subnormal but a delayed response.

The question naturally arises whether the diminished response to heparin is the expression of a change in the clotting factors preceding or following thrombosis. An oppor-

tunity presented itself during the treatment of varicose veins to inquire into this problem. It is our custom to ligate the saphenous vein at its junction with the femoral and then inject rather large amounts of hypertonic solutions to produce a thrombosis of at least the segment of the saphenous vein ending at the knee. Thus a rather massive thrombus is produced. It is interesting to note that the presence of such large masses of thrombus does not alter the heparin curves after their production. Figure 7 shows an average of three curves before and 24 hours after vein ligation and massive injection. This graph illustrates the fact that minor operations with slight tissue injury do not alter the postoperative heparin curve and also that the presence of a massive thrombus itself does not seem to influence it. It must be emphasized, however, that such an artificial thrombus differs from a spontaneous one in that an irritative endophlebitis has been the primary cause of thrombosis and that this thrombus is not in

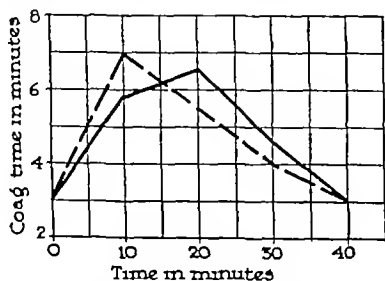


Fig 7 Heparin curves, average, in 3 cases before (—) and after (---) ligation of saphenous vein followed by retrograde thrombosis. Note that there is little, if any, change in the response to heparin.

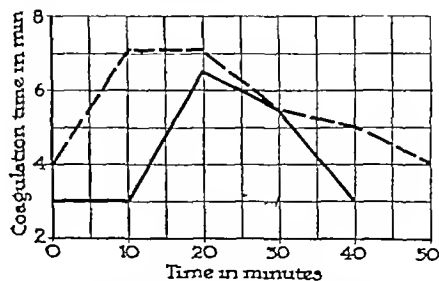


Fig 8 Note that following ligation of the femoral vein the delayed response to heparin becomes normal. The thrombosis has been eliminated from contact with circulating blood. —, Before ligation. ---, after ligation.

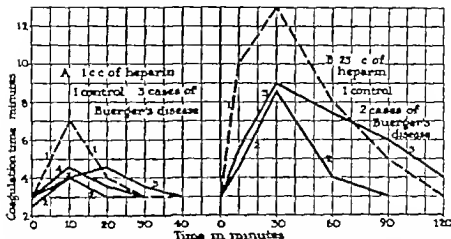


Fig. 9. a, Heparin curves in Buerger's disease. Case 2 is in quiescent stage. Cases 1, 3, and 4 are examined in acute phase of the disease. On the right side of the graph, b, one can observe that larger doses of heparin (25 c.c.) also meet increased resistance in Buerger's disease. Should such patient be heparinized, larger or more frequent doses are necessary to effect satisfactory prolongation of coagulation time.

contact with the general circulation as the vein above the clot is tied and cut. Thus any kinase generated in the thrombus cannot be absorbed from here as even the perivascular lymphatics are blocked by the transection of the vein. This possibility is suggested by the curves of R. B. a patient suffering from a deep venous thrombosis of about 10 days duration. His heparin response was slightly delayed. At 10 minutes there had been no rise of the clotting time although at 20 minutes a good response had been elicited. However 24 hours after the femoral vein had been tied and the thrombus thus eliminated from contact with the circulating blood, the response was far quicker and lasted longer (Fig. 8).

**C. Buerger's disease.** Six patients are available for study (Fig. 9). In a, are shown 4 cases. Case 1 L. F. a 50 year old male had acute and recurrent attacks of Buerger's disease for many years. At the time of examination the process was entirely quiescent with a normal sedimentation rate. There were multiple segmental occlusions. Case 2 P. B. was examined during a recurrent attack. Case 3 B. W. had a marked peripheral type of Buerger's disease with acute swelling pain and rubor of toes. Case 4 M. M. developed a segmental phlebitis in one arm with previously closed pedal arteries. With the exception of

the first patient all others represent an active stage and show a diminished response to heparin. In b 2 other patients are shown who happened to receive 25 cubic centimeters of heparin. To this dose both of them show a diminished response. As a control an average of 5 normals is shown when this dose is given. Case 5 N. F., is a moderate progressive type of Buerger's disease necessitating a sympathectomy. Case 6 J. D. is a severe juvenile Buerger's disease with involvement of all four extremities the coronary and retinal vessels.

It is notable that without exception patients suffering from Buerger's disease unless they are in a stage of complete remission, are hyporeactors. It is possible that with increasing experience the heparin response may prove to be a good measure of the activity of the disease.

#### THE HYPERREACTOR GROUP

When the coagulation curve reached or exceeded the level of 7½ minutes after the injection of 1 cubic centimeter of heparin the patient was labeled as a hyperreactor. The dividing line between normal and hyperreactors is of course entirely arbitrary. We have seen in this group of 87 patients 8 individuals whose reaction to heparin was exaggerated. Together with the increased

response to such a small dose of heparin 7 of the 8 patients showed flushing of the face, dyspnea, choking, constriction of the chest, and a feeling of faintness, characteristic of sensitization phenomena. That these clinical symptoms should be accompanied by a prolongation of coagulation time is significant in the light of a similar clotting phenomenon in anaphylactic reactions.

Figure 10 shows the curve of some of these patients. Patients 1 to 4 were severe hypertensives. Patient 5 was a diabetic, a pituitary dwarf. Patient 6 had undiagnosed attacks of dyspnea and fainting and a 5 per cent eosinophilia. She showed a marked allergy to heparin. Patient 7 had varicose veins with no history of any allergy. Six of the 8 patients had never received any heparin before. The other 2 had had injections of heparin less than a week prior to the dose which produced the reaction. The first dose did not produce any symptom nor was the curve obtained higher than normal.

#### CLINICAL APPLICATION OF HEPARIN CURVE

The graphs presented allow certain conclusions, whereas, many other angles of this problem are now being studied. One obvious conclusion is the great variability of the individual in its response to heparin. Of the 87 patients, only 47 acted normally, 36 were hyporeactors and 8 showed an exaggerated response. The large number of abnormal responses is naturally related to the type of material studied.

Of considerable surgical interest is the finding of the heparin resistance during the first 3 or 4 days following major operations. Many operations, especially those in which minimal tissue damage is produced, do not show a flattening of these curves. This hyporeactivity to heparin occurs simultaneously with a slight but definite lowering of the platelet count and probably other physicochemical changes, all of which relate to trauma to the tissues. It is our impression that postoperative thrombosis starts at this early period and not between the 6th and 10th days when the prothrombin level increases concomitantly with a thrombocytosis (14). It is likely that this is the period when the initial

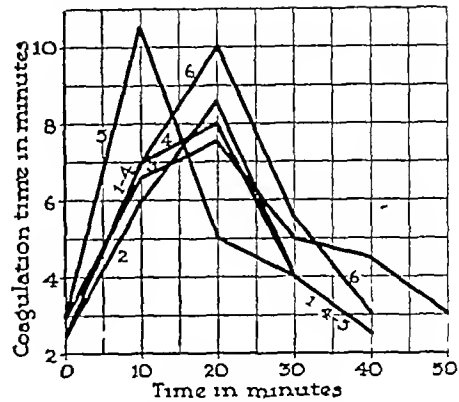


Fig. 10. The curves of 6 patients, showing increased sensitivity to heparin. This hyperreactor group showed phenomena of sensitization and constituted approximately 10 per cent of the total material studied.

thrombus becomes clinically manifest as it spreads to longer segments of the vein. Obviously then, patients are most in need of heparin during the first 3 days after operation. If they can be mobilized after this period the administration of heparin may be discontinued. While we have heparinized patients for 10 to 12 days after operation, during the last year we have limited its administration to the first 3 days. This method, of course, is only applicable to the prevention of thrombosis and not to its treatment, which should be carried out until the thrombus is reasonably firm, namely, 10 to 12 days. Even so, cases are on record in which emboli appeared 20 to 30 days after a clinically manifest thrombosis. For a prolonged treatment with anticoagulants, heparin is not as suitable as the orally administered dicoumarin.

In this paper, we are not discussing the action of dicoumarin, the extract of spoiled sweet clover, except as it relates to the administration of heparin. The literature on dicoumarin has been summarized recently in a number of papers (1, 2, 10, 16). While dicoumarin is easy to administer by daily oral doses, the dosage is difficult to control. In fact, at present it is unsafe to administer it at all, without a daily determination of the prothrombin level, which limits its use to large hospitals. In our experience, purpura, hemorrhages, toxic rashes may occur. There is a marked variability of individual response.

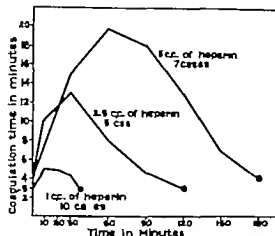


Fig. 1. The effect of increasing doses of heparin on the duration of prolonged coagulation time. 1. This small dose, the effect of cubic centimeter (1 mgm.) was off in 40 minutes, of 5 cubic centimeters (5 mgm.) in 3 hours, and of 5 cubic centimeters (50 mgm.) in 3 hours.

One patient who received a single 200 milligram dose of dicoumarin showed a prolongation of prothrombin time from 18 to 60 seconds with the Smith bedside test. Another patient who was maintained on daily doses of 100 milligrams with a satisfactory level of prothrombin, suddenly became resistant to this dose following an amputation and in fact developed an embolus while receiving the drug. We mention this only to indicate the difficulty of administration. At present we use heparin in intermittent doses for 3 days following an operation, which we suspect might lead to thrombosis. The selection of this endangered group is made by (1) a flat preoperative heparin curve (2) history of previous thromboses and (3) certain operations or injuries in older age groups which are followed by a high incidence of thromboses such as abdominal hysterectomies, ventral herniotomies, fractured pelvis or hips. Certainly no one could run heparin curves before every operation.

In the treatment of an existing thrombosis, venous or arterial we again heparinize the patient for 3 days, but simultaneously administer dicoumarin by mouth. One can give 300 milligrams the first and 100 milligrams the second day or as State and Bullowa proposed, give a single dose of 400 milligrams the effect

of which lasts approximately 6 days. In spite of negative liver function tests during the administration of this drug (1, 2, 10, 16) the presence of liver damage cannot be excluded. Great caution is recommended in using this drug for more than a short time such as for weeks and months in small doses. A prothrombin level of around 40 seconds (50 per cent of normal) should be maintained.

The occurrence of sensitization phenomena following the use of heparin makes it imperative to use a small dose such as we have suggested before therapeutic or prophylactic heparinization of the patient is started. The purest preparations of heparin contain about 2 per cent nitrogen (Jorpes). Six of our 8 patients with allergic reaction had never had heparin before. If heparin is normally secreted into the blood stream, could a sensitization occur to the endogenous product? This question needs further study.

Nothing has been said so far about the method of administering heparin. We start now with the determination of a heparin curve with 1 cubic centimeter of the drug. If the patient shows a normal reaction to heparin, 5 cubic centimeters (50 mgm.) are injected intravenously every 3 or 4 hours during day and night. A coagulation time should be determined 1 hour after the injection and at least once more just before the next dose is given. The effect of 10 milligrams of heparin wears off in 40 minutes of 25 milligrams in 2 hours, of 50 milligrams in 3 hours (Fig. 1). It is important not to inject the following dose of heparin until the coagulation time has returned to its normal level as otherwise a step-ladder type of elevation will result with coagulation times that are far too excessive. The reports on hemorrhages following the use of heparin are quite numerous (6, 8, 3). We have observed 3 severe hemorrhages requiring multiple blood transfusions before these precautions were observed. More than 50 milligrams of heparin need not be injected at one time. The 100 milligram doses given by some of the Scandinavian authors may produce excessive and dangerous elevation of the coagulation time.

Two of these have been tried, of which was one.

intravenous drip, which is still the most popular. The method is cumbersome for the patient, requires a special nurse to watch the rate of inflow and in spite of this precaution still results in marked fluctuations of coagulation time. We have kept patients for as long as 12 to 14 days under continuous intravenous administration, but the number of chills, reactions, and the painful immobilization of the arm have made us abandon this procedure.

One can also maintain an increased level of coagulation time by giving an initial dose of 25 milligrams and follow this 45 to 60 minutes later with hourly doses of 10 milligrams given intravenously. This type of administration would require hourly intravenous injections and would not be practical in hospitalized patients. During conditions of war, especially during transport, such a method has been suggested by Murray and Janes on the basis of animal experiments. One can maintain a coagulation time between 6 and 14 minutes with this procedure.

#### SUMMARY

1. A simple test of the clotting mechanism is suggested. A small amount of heparin is injected intravenously and coagulation times are determined at 10 minute intervals for 40 minutes.

2. A group of heparin resistant patients have been found. They are patients in the early postoperative period, patients following

cardiovascular accidents, and patients suffering from Buerger's disease.

3. Conversely a group of hyperreactors have been discovered, who showed sensitization phenomena. They may have had or never had received heparin previously.

4. Some suggestions are made for the clinical use of heparin. A combination of heparin and dicoumarin is advocated.

#### REFERENCES

- 1 ALLEN, E. V., BARKER, N. W., and WAUGH, J. M. *J Am M Ass*, 1942, 120: 1009.
- 2 BOLLMAN, J. L., and PRESTON, F. W. *J Am M Ass*, 1942, 120: 1021.
- 3 CRAWFORD, C., and JORPES, E. *J Am M Ass*, 1941, 116: 2831.
- 4 D'ALESSANDRO, A. *J Surg Gyn Obst.*, 1942, 74: 62.
- 5 DE TAKATS, G. *Thrombosis and embolism in* Christopher, F. *Textbook of Surgery*, 3d ed Philadelphia W B Saunders & Co., 1941.
- 6 FRESHER, I., and BLAISDELL, I. *J Am M Ass*, 1941, 117: 927.
- 7 JORPES, I. *Heparin, its Chemistry, Physiology and application in Medicine* London Humphrey Milford, Oxford University Press, 1939.
- 8 KELES, J. W., and SHAFFER, C. F. *J Am M Ass*, 1942, 119: 882.
- 9 MASON, M. F. *Surgery*, 1939, 5: 531 and 618.
- 10 MEYER, O. O., BINGHAM, J. B., and AXELFORD, V. H. *Am J M Sc*, 1942, 204: 11.
- 11 MURRAY, G. *Arch Surg*, 1940, 40: 307.
- 12 MURRAY, G., and JAMES, J. M. *Brit. M J*, 1942, 2: 6.
- 13 RICHMOND, E. L. *J Am M Ass*, 1941, 118: 611.
- 14 SHAPIRO, S., SHERWIN, B., and GORDIMER, M. *Arch Surg*, 1942, 116: 175.
- 15 STAFF, D., and BULLOWA, J. *Proc Soc Exp Biol N Y*, 1942, 50: 66.
- 16 WRIGHT, I. S., and PRANDONI, A. *The dicoumarin 3,3'-methylene bis (4 hydroxycoumarin)* *J Am M Ass*, 1942, 120: 1015.

# V-SHAPED OSTEOTOMY FOR CORRECTION OF OPEN BITE IN ADULTS

KURT H. THOMA, D.M.D., Boston, Massachusetts

**O**PEN bite or apertognathia, is a condition in which there is a space between the upper and lower jaw that is between the maxillary and mandibular anterior teeth when the posterior teeth are in contact. Those having this deformity which first of all tends to impair their appearance are unable to incise that is, to bite off food such as a piece of apple. They may have difficulty with mastication in general, and often have speech defects. Some are mouth breathers, not being able to keep their lips occluded and are liable therefore to suffer from chronic pharyngitis, tonsillitis and adenoids. The deformity may be due either to malformation or to improper reduction and immobilization of a fracture of the maxilla or mandible.

## MALFORMATION

In many cases open bite is believed to be due to thumb and finger sucking and abnormal tongue habits. There is considerable clinical evidence, however, that open bite in many cases is due to inhibited development of the premaxillary area, which is derived from the frontonasal process in the embryo (Fig. 1). This underdevelopment may be due to diseases affecting the normal development of the skeleton and causes arrested vertical growth of the alveolar process and teeth in this region. It is often associated with hypoplastic defects in the enamel and has been observed in rickets (Fig. 2). In another case of rickets open bite was found to be due to a downward bending of the lower jaw caused by the pull of the depressor muscles.

In determining the etiological factors in these cases it should be remembered that tongue habits may have developed because of the malformation rather than caused by it although it must be admitted that they prob-

ably act as a contributory cause in most cases. In these malformations the open bite always causes an angulation in the occlusal curve in either the upper or lower jaw or both. A distinct downward bend in the anterior part of the mandible is known as *ectopia of the jaw*.

Another type of open bite is said to be caused by arrested vertical development of the ramus. This malformation is characterized by the fact that only the last molars on each side are in occlusion and the rest of the bite is open the space between the teeth increasing gradually without there being any angulation. A case of this type of malformation is shown in Figure 3.

According to an analysis of 115 children with open bite made by Swenchart, 73 involved the incisors only, 25 the incisors and canines, 11 the incisors, canines and one or both premolars and in 1 case the malformation included the first molar. The remaining 5 cases did not include the anterior region.

## MALUNITED FRACTURES

Open bite may be the result of faulty reduction or poor immobilization with ineffective control of muscle pull. It occurs in three types of fractures, as follows:

1. In complete horizontal fracture of the maxilla, when the pull of the pterygoid muscles causes a backward and downward displacement of the posterior part of the upper jaw opening the incisor bite (Fig. 4). This deformity can best be remedied by refracturing the maxilla by horizontal submucosal division of the five vertical walls: the outer surface on both sides, and the nasocentral walls of the upper jaw and the nasal septum.

2. In fractures of the horizontal ramus, if the downward pull of the anterior part of the mandible by the depressor muscles of the jaw is not effectively prevented by proper fixation on the anterior part of the dental arch (Fig. 7).



Fig 1



Fig 2



Fig 3



Fig 4



Fig 5



Fig 6



Fig 7

Fig 1 Underdevelopment of the premaxilla causing open bite

Fig 2 Child, 11 years old with a history of rickets, presents underdevelopment of the premaxilla and hypoplastic defects in the incisor teeth

Fig 3 Open bite due to arrested vertical development of the ramus only the third molars occlude in this case

Fig 4 Open bite resulting from improper reduction of horizontal fracture of mandible

Fig 5 Bilateral fracture posterior to the second molar with malunion causing open bite

Figs 6 and 7 Patient sustained a triple fracture of the mandible at the symphysis and neck of the condyle on each side The x ray examination disclosed overriding (Fig 6) which caused open bite (Fig 7)

3 In bilateral fracture of the neck of the condyle These cases are very frequent In most of them the elevator muscles of the jaw cause overriding (Fig 5) As a result, the ramus is shortened, and with the posterior molars acting as a fulcrum the upper and lower incisors are drawn apart (Fig 6) In immobilizing such a fracture it is extremely important to prevent gradual opening of the bite through the action of the elevator mus-

cles, the effect of which is increased if trismus sets in The bite tends to open up when the intermaxillary ligation in the anterior region is not strong enough to overcome the tension of the muscle pull

It is clear that in malunited fractures there are again two types of open bite In one there is a gradual opening of the entire occlusal plane, due either to displacement of the maxilla or to shortening of the ramus In the other



# V SHAPED OSTEOTOMY FOR CORRECTION OF OPEN BITE IN ADULTS

KURT H. THOMA, D.M.D. Boston, Massachusetts

**O**PEN bite or apertognathia, is a condition in which there is a space between the upper and lower jaw that is between the maxillary and mandibular anterior teeth when the posterior teeth are in contact. Those having this deformity which first of all tends to impair their appearance are unable to incise that is, to bite off food such as a piece of apple. They may have difficulty with mastication in general and often have speech defects. Some are mouth breathers, not being able to keep their lips occluded and are liable therefore to suffer from chronic pharyngitis, tonsillitis, and adenoids. The deformity may be due either to malformation or to improper reduction and immobilization of a fracture of the maxilla or mandible.

## MALFORMATION

In many cases open bite is believed to be due to thumb and finger sucking and abnormal tongue habits. There is considerable clinical evidence, however, that open bite in many cases is due to inhibited development of the premaxillary area, which is derived from the frontonasal process in the embryo (Fig. 1). This underdevelopment may be due to diseases affecting the normal development of the skeleton and causes arrested vertical growth of the alveolar process and teeth in this region. It is often associated with hypoplastic defects in the enamel and has been observed in rickets (Fig. 2). In another case of rickets open bite was found to be due to a downward bending of the lower jaw caused by the pull of the depressor muscles.

In determining the etiological factors in these cases, it should be remembered that tongue habits may have developed because of the malformation rather than caused by it, although it must be admitted that they prob-

ably act as a contributory cause in most cases. In these malformations the open bite always causes an angulation in the occlusal curve in either the upper or lower jaw or both. A distinct downward bend in the anterior part of the mandible is known as *eclopia* of the jaw.

Another type of open bite is said to be caused by arrested vertical development of the ramus. This malformation is characterized by the fact that only the last molars on each side are in occlusion and the rest of the bite is open, the space between the teeth increasing gradually without there being any angulation. A case of this type of malformation is shown in Figure 3.

According to an analysis of 115 children with open bite made by Swinchart, 73 involved the incisors only, 25 the incisors and canines, 11 the incisors, canines, and one or both premolars, and in 1 case the malformation included the first molar. The remaining 5 cases did not include the anterior region.

## MALUNITED FRACTURES

Open bite may be the result of faulty reduction or poor immobilization with ineffective control of muscle pull. It occurs in three types of fractures as follows:

1. In complete horizontal fracture of the maxilla when the pull of the pterygoid muscles causes a backward and downward displacement of the posterior part of the upper jaw opening the incisor bite (Fig. 4). This deformity can best be remedied by refracturing the maxilla by horizontal submucosal division of the five vertical walls, the outer surface on both sides, and the nasointral walls of the upper jaw and the nasal septum.

2. In fractures of the horizontal ramus if the downward pull of the anterior part of the mandible by the depressor muscles of the jaw is not effectively prevented by proper fixation on the anterior part of the dental arch (Fig. 7).

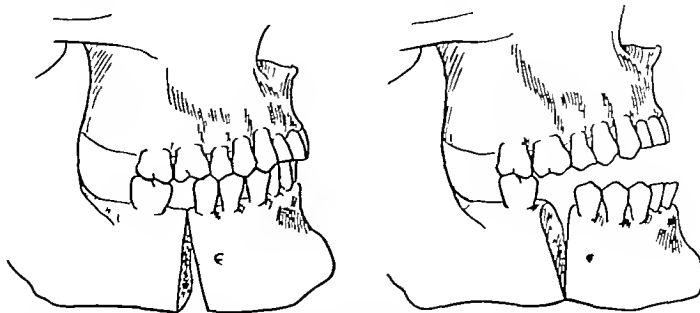
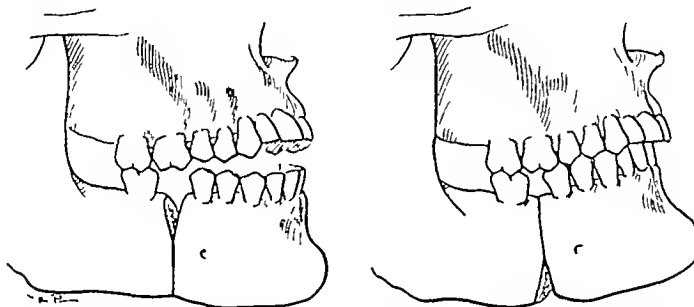


Fig 12, left Simple bilateral osteotomy causes V shaped space to open when the anterior fragment is placed in position

Fig 13 Correction of open bite by a V shaped excision of bone



Figs 14 and 15 Correction of open bite by Y shaped excision in the horizontal ramus

performed by Blair (1897) This and another operation were reviewed by Angle (1, 2) in 1898 One operation was performed at the Baptist Hospital in St Louis, with excellent results, the other was performed at a hospital in New Orleans, and nearly cost the patient his life, with total loss of the mandible through necrosis Failure was due to the fact that practically no support was given the segments of bone, Barton bandage and wiring of bone being depended upon for stabilization (A crude wire ligature was placed on each side, but one dropped out 3 days after the operation) Angle emphasized the importance of proper stabilization of the fragments after operation, and of removing a complete V-shaped or wedge-shaped section of bone

Since that time only occasional reports on the surgical treatment of malformed jaws have appeared in the literature Most of these articles deal with the lengthening or shortening of the jaws to correct either macrognathia or micrognathia—that is, protrusion or retrusion of the mandible—although open bite is

occasionally included because it is likely to be combined with mandibular protrusion In 1901 von Eiselsberg performed an operation similar to that of Hüllihen on an ectopic mandible, the cause of which was a dermoid cyst Lane, in 1905, and Pickerill, in 1912, who mentions the former, both performed wedge-shaped excisions in the premolar region extending through the whole thickness of the mandible Mayrhofer, in 1916, also recommended the resection of a wedge-shaped section to transpose the anterior part of the jaw, but believed that the first molars should be extracted previously Korth, in 1921, favored an operation in the horizontal ramus because it is the part of the bone involved in the anomaly Blair, in his book, *Surgery and Diseases of the Jaws* (1927), recommended for certain cases a simple bilateral section of the horizontal ramus This allows one to move the detached part of the jaw up into occlusion The operation, however, is applicable only to cases in which the jaw does not need to be tilted, or set back Many cases of open bite,



Figs 8 and 9. Correction of open bite according to Hüllihen. V-shaped section of thirds through mandible

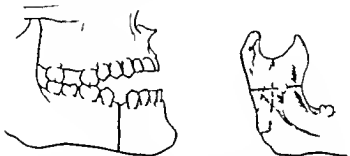


Fig. 14. left. Correction of open bite. Simple osteotomy according to Blair and vertical displacement of anterior fragment.

Fig. 15. Three methods for correction of open bite in the ramus. 1, horizontal osteotomy first described by Balbock; 2, oblique osteotomy in ramus after Lushberg; 3, oblique osteotomy at neck of the condyle according to Kozloff.

there is an angulation of the horizontal part of the mandible either within or directly behind the dental arch. The two types, no matter whether they are caused by maldevelopment or by fracture, should be differentiated since they require different kinds of treatment.

#### ORTHODONTIC TREATMENT

In children up to 12 or 14 years of age, malformations can be corrected by orthodontic procedures which tend to activate the underdeveloped section of the jaw and by eliminating tongue habits which may interfere with the treatment. The older the patient the less favorable is the outlook for obtaining a satisfactory result.

#### SURGICAL TREATMENT

In adults, excellent results can be obtained by surgical procedures. Operation, however, is indicated only in severe cases in order to correct definite disabilities which include

psychoses, the basis of which is the unattractive appearance caused by the deformity.

The first operation devised to improve a malformation of the jaw by surgical means was reported by Hüllihen in 1849. The patient, a girl 20 years old, had a deformity due to traction caused by a scar from a burn on the neck received 15 years previously. The mandible was bent down and the bite was open. The operation performed without anesthesia and at a time when hemostatic forceps and antiseptics were unknown, consisted of the resection of a V-shaped section from each side of the mandible including on one side a premolar tooth. This section extended only two-thirds of the way through the bone at which point the saw was turned horizontally forward. Removal of the sections of bone permitted the loosened anterior portion of jaw to be pushed back and up (Figs. 8-9).

Although this operation was successful almost 50 years elapsed before a similar one was

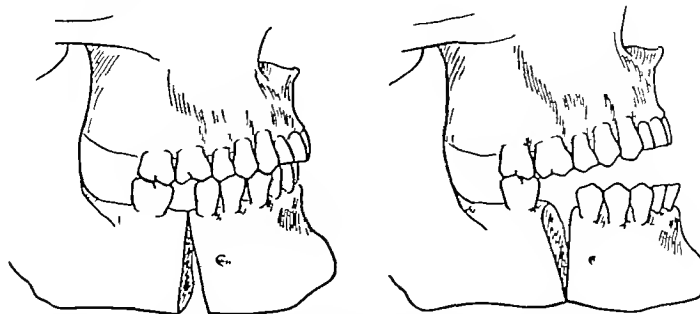
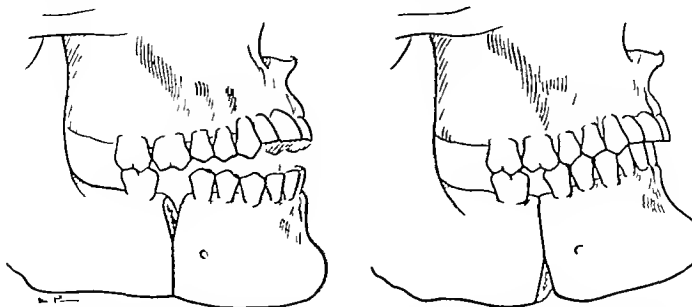


Fig 12, left Simple bilateral osteotomy causes V shaped space to open when the anterior fragment is placed in position

Fig 13 Correction of open bite by a V shaped excision of bone



Figs 14 and 15 Correction of open bite by Y shaped excision in the horizontal ramus

performed by Blair (1897) This and another operation were reviewed by Angle (1, 2) in 1898 One operation was performed at the Baptist Hospital in St Louis, with excellent results, the other was performed at a hospital in New Orleans, and nearly cost the patient his life, with total loss of the mandible through necrosis Failure was due to the fact that practically no support was given the segments of bone, Barton bandage and wiring of bone being depended upon for stabilization (A crude wire ligature was placed on each side, but one dropped out 3 days after the operation) Angle emphasized the importance of proper stabilization of the fragments after operation, and of removing a complete V-shaped or wedge-shaped section of bone

Since that time only occasional reports on the surgical treatment of malformed jaws have appeared in the literature Most of these articles deal with the lengthening or shortening of the jaws to correct either macrognathia or micrognathia—that is, protrusion or retrusion of the mandible—although open bite is

occasionally included because it is likely to be combined with mandibular protrusion In 1901 von Eiselsberg performed an operation similar to that of Hüllihen on an ectopic mandible, the cause of which was a dermoid cyst Lane, in 1905, and Pickerill, in 1912, who mentions the former, both performed wedge-shaped excisions in the premolar region extending through the whole thickness of the mandible Mayrhofer, in 1916, also recommended the resection of a wedge-shaped section to transpose the anterior part of the jaw, but believed that the first molars should be extracted previously Korth, in 1921, favored an operation in the horizontal ramus because it is the part of the bone involved in the anomaly Blair, in his book, *Surgery and Diseases of the Jaws* (1927), recommended for certain cases a simple bilateral section of the horizontal ramus This allows one to move the detached part of the jaw up into occlusion The operation, however, is applicable only to cases in which the jaw does not need to be tilted, or set back Many cases of open bite,



Fig. 6

Fig. 6. Mouth of patient aged 8 years showing open bite deformity



Fig. 7



Fig. 8

Fig. 7 and 8. Lateral view of the patient with open bite. The ramus extends to the first molar region.

however are associated with some mandibular protrusion even if not marked and if the anterior segment in such cases is not tilted back the lower incisors will protrude over the upper ones when brought into position. The illustration of Blair of which Figure 10 is a copy is a good example of the fact that simple osteotomy does not correct open bite satisfactorily. Blair himself stated that if the jaw needs to be tilted as it does in most cases it is necessary to remove a V-shaped section. If the jaw were tilted back after a simple osteotomy without a V-shaped resection a reversed V would open at the lower border of the mandible as shown in the case described by Bruhn in 1927 and illustrated in Figure 12. The resulting inadequate apposition of the fragments would prevent healing in many cases. The resection of a V-shaped piece of bone as shown in Figure 13 has therefore been recommended by all who describe operations in the horizontal ramus. Blair recommends in addition an S-shaped cut which he states, has the advantage of not shortening the jaw. Kazanjian in 1932 attempted a semi-circular incision on one side with a special trephine, on the other side a surgical bur was used. The cutting with the trephine he stated was disappointing but the bur worked very satisfactorily.

An entirely different approach has been suggested by Babcock 1909. He described the case of a boy of 18 on whom he performed a bilateral transverse section of the ramus (Fig. 11 line 1). He chose this operation to avoid reduction of the size of the dental arch and injury of the inferior alveolar nerve and ves-

sels. He states however that the operation in the ramus is indicated only in cases in which careful study shows that a fair occlusion can be attained without changing the angulation of the dental arch.

Limberg 1926 a Russian surgeon also advised that an operation be performed in the ramus, but again only for cases in which open bite is caused by deficiency in that part. His operation to elongate the ramus consists of an oblique osteotomy performed from an incision below the angle of the jaw. The bone is cut beginning at the mandibular notch, with a backward and downward sloping to the posterior margin of the ramus (Fig. 11 line 2). Limberg pointed out that obstacles to success with this method are the stylo-mandibular ligament and the elevator muscles attached to the posterior part of the jaw which may prevent the bringing down of the mandible. The muscles may gradually cause retraction after the operation for which reason he recommended overcorrection. Kostetka, 1934 like Babcock favored an operation beyond the dental arch. He recommended a section at the neck of the condyle (Fig. 11 line 3). This operation as well as Babcock's can be performed with a Gigli saw and has the advantage of an easy technique. None of the operations performed in the ramus, however allow a change in the angulation of the mandible. They are indicated therefore only for cases in which the deformity is due to underdevelopment or shortening of the ramus and not for the commoner type of open bite in which angulation in the dental arch has to be overcome.



Figs. 19, left, and 20 Roentgen examination of the jaws showing contact of the molars, caries in the left first molar underneath a filling, and a thick, heavy cortex of the jaw

*Planning of treatment* The treatment should be carefully planned after a thorough study has been made of the deformity. Open bite due to underdevelopment or shortening of the ramus should be carefully distinguished from that due to angulation within the dental arch. The first type of deformity calls for correction in the ramus, the second for an osteotomy just anterior to the last tooth in occlusion. As the simple osteotomy is inadequate in most cases, excision of a section of bone is indicated to allow tilting up of the anterior part of the jaw. The V-shaped excision, which is generally performed from an intraoral approach, has two decided disadvantages. First, it involves the mandibular nerve and artery, which are generally severed, second, it causes considerable retrusion and slanting of the lower incisor teeth, owing to the amount of tilting necessary to correct excessive open bite when associated with only moderate or no mandibular protrusion. The latter disadvantage may be overcome by a modification of the conventional procedure consisting of a combination of the V-shaped excision and straight osteotomy, a method that may be designated as the Y-shaped excision.

#### Y-SHAPED EXCISION IN HORIZONTAL RAMUS

The Y-shaped excision has the advantage of facilitating the preservation of the mandibular nerve and artery and of causing only a small amount of retrusion of the jaw. While the numbness from cutting the mandibular nerve which generally follows complete sectioning of the jaw from an intraoral or extra-

oral approach is not usually permanent, it causes embarrassment to the patient because of the dribbling of saliva and dropping of food associated with it. Avoidance of this complication is therefore highly desirable.

This operation is especially indicated in cases of open bite with little or no mandibular protrusion, but it can be adapted to cases in which protrusion is marked. In such cases a rhomboid section is removed in two parts, in a similar manner as New and Erich, 1941, excised a parallel section for correction of prognathism. The first part of the rhomboid piece, wider on the top than on the bottom, is removed by an intraoral approach above the mandibular canal, the second and narrower part below the mandibular canal is excised by an extraoral approach. The operation serves to shorten the jaw and at the same time to tilt it up without injury to the nerve and vessels.

*Technique* The Y-shaped excision consists of an intraoral and an extraoral operation, performed on both sides of the jaw. After the former is finished the latter follows with a complete new sterile set-up. This procedure may take a little longer than the V-shaped excision, which can be done intraorally, but it repays extra time by giving a much better result.

The intraoral stage consists of cutting out a short V-shaped piece, the apex of which extends to the mandibular canal. The lower part of the mandible is cut in a vertical direction from the inferior border up to the mandibular canal, leaving a thin strand of



Fig. 1. Splint designed by Dr. Maynard E. Cohen inserted before the operation.

bone which contains the nerve and artery (Figs. 14 and 15). This bridge can be fractured by forcing the anterior part of the mandible into the correct position as will be described. On positioning of the mandible the V-shaped space in the alveolar process closes and a reversed V-shaped space opens at the lower border of the jaw.

The operation is performed at the place where the mandible is angulated or where the open bite begins. Unless there is an edentulous space on one or both sides a tooth must be extracted. This can be done 2 or 3 weeks before the operation or at the time the osteotomy is performed. An arch wire splint however must be constructed and cemented in place beforehand.

#### ILLUSTRATIVE CASE

The case used to illustrate this procedure is that of a patient 18 years of age who when young had a habit of thrusting his tongue between his teeth. He was in perfect health but had been rejected by the Air Corps because of an open bite extending from the first

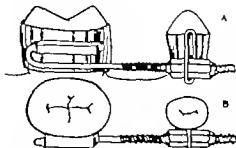


Fig. 2. Accessory to the splint applied immediately after the operation to hold fragments in contact.

molars forward as shown in Figures 16, 17 and 18. He came to me with the request to have this deformity corrected surgically. X-ray photographs were taken of both sides (Figs. 19 and 20). I decided to remove the first molar on each side in order to create the necessary space to perform the V-shaped excision just described. One of the molars was affected by deep secondary caries, and there appeared to be a good chance that the third molars, when erupting, would push the second molars forward and partly close the space.

*The splint.* A splint was designed and constructed by Dr. Maynard E. Cohen. It consisted of bands cemented to anchor teeth to which an arch wire was connected. The arch wire contained lugs for intermaxillary ligations as shown in Figure 21. In the mandible it extended only to the tooth behind which the osteotomy was to be performed. A second detachable and adjustable appliance was prepared which has the purpose of drawing and holding the cut ends of the mandible in contact. The end of this appliance was made to fit into a square tube soldered to the molar



Fig. 3.



Fig. 4.

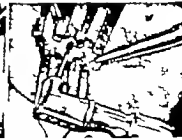


Fig. 5.

Fig. 3. Gingival flap prepared on buccal side of the lower first molar.

Fig. 4. After extraction of the first molar, V-shaped

section of bone as removed.

Fig. 5. Incision at the lower border of the mandible and cutting drill holes through the lower part of the bone.



Fig 26, left Vertical cut completed with bone chisel

Fig 27 Incision closed with rubber-dam drain inserted

band This arrangement made it possible to place the extension wire bar in any of three positions, so that it could be placed over, under, or on the buccal side of the tube The anterior threaded part was made to pass into a vertical loop soldered to the premolar band This made it possible to lock the appliance by turning the two nuts on each side of the loop against each other when the artificial fracture had been properly reduced (Fig 22)

*The operation* Intravenous pentothal sodium anesthesia was administered by Dr Lewis Dretler Intravenous anesthesia eliminates vomiting, which is undesirable when intermaxillary ligation is employed The patient had the usual preoperative medication with atropine, 1/100 grain The pentothal was given in fractional doses by means of an intravenous drip, which maintains water balance An endotracheal catheter was inserted through the nose so that the throat could be packed to prevent aspiration of blood and fluids during the operation Some nitrous oxide and oxygen or plain oxygen was also administered at intervals during the operation through this tube

The intraoral procedure consisted of the extraction of the tooth on each side A gingival flap was first prepared by making incisions at the anterior and posterior limit of the tooth socket on the buccal side, carrying them down over the alveolus in a divergent manner so that the pedicle of the flap was wider than the peripheral end (Fig 23) The bone was thus exposed and a V-shaped section cut out on each side by means of burs and a chisel (Fig 24) Care was exercised not to cut beyond the mandibular canal

The extraoral procedure was done with a new sterile set-up, including instruments An incision 5 to 6 centimeters in length was made below the inferior border of the mandible, its outer surface being exposed without cutting the external maxillary artery After carefully locating the apex of the V so as to connect with it, a vertical incision was made in the periosteum The cortex of the bone was then perforated with a bur (Fig 25), after which the chisel was used to complete the cut (Fig 26) This required considerable force, since the cortex of the patient's jaw was unusually heavy, as seen in the x-ray films of the mandible The bone, although cut from both sides, was not completely severed at this time, however, a little span was left, protecting the nerve and vessels of the jaw After the vertical cut had been completed on the other side of the jaw in the same way, the chin was pressed upward with one hand to complete the artificial fracture It was necessary to aid this procedure by inserting a chisel into the cut, first on one side and then on the other, in order to apply force on the anterior segment The detached part was now very loose, and care had to be exercised so as not to displace it, for fear that the nerve and artery might be drawn out of the canal and later form a loop that might be caught between the fragments when brought together While the chin was supported by the assistant, the skin incisions were closed with sutures Rubber-dam drains were next inserted between the sutures on each side to prevent the formation of a hematoma (Fig 27)

*Immobilization* The operation was continued in the mouth First, the mucosa was





Figs. 28, left, and 29. Anterior part of the mandible positioned and stabilized by the appliance.



Figs. 30, left, and 31. Roentgen examination 6 weeks after the operation at the time when the appliances were removed.

sutured into place on each side with silk. Then the mandible was placed so that the teeth attained the best occlusion possible. The detachable appliances were inserted and adjusted to bring the posterior fragments into good contact with the anterior one. Care was taken to bring the posterior mandibular molars into occlusion with the maxillary ones. The premolars had to be shaped by judicious grinding so as to occlude with their antagonists. This is necessary in most cases because teeth that have never occluded may not fit properly when brought together. The jaws were completely immobilized by intermaxillary ligation (Figs. 28 and 29). The intermaxillary wires were placed so that there was firm and strong fixation in the incisor region to counteract the pull from the geniohyoid and digastric muscles.

*Postoperative care.* There was only slight edema following the operation. Ice was applied to the jaw for the first 24 hours. In spite of all precautions, such as the use of the endotracheal tube, aspiration of accumulated mu-

cus in the bronchi after the operation and changing the patient's position in bed every half hour while he was unconscious, he developed pneumonia on the second day. The temperature was 106.5 degrees F, pulse 160, respirations 60, and x-ray examination showed evidence of lobar pneumonia. The white cell count was 12,400 with 86 per cent neutrophils, 5 per cent young neutrophils, and 9 per cent lymphocytes. Fluids were given intravenously and at the recommendation of Dr. C. A. Janeway, 5 grams of sulfadiazine was administered promptly by the same method. An oxygen tent was installed and the sulfadiazine was continued, two tablets being given by mouth every 4 hours. The sulfadiazine level in the blood was maintained between 10 and 12 milligrams per 100 cubic centimeters. Dr. R. H. Overholt was asked to take charge of the pulmonary complications, and owing to his skillful treatment combined with careful nursing, the patient completely recovered. He was discharged one month after admission.



Figs 32, left and 33 Photographs taken 5 months after the operation showing correction of open bite



Figs 34, left, and 35 Roentgen examination 5 months after operation showing complete filling in of the bone

The drains were removed on the 2d postoperative day, and when the patient was able to take nourishment a liquid diet was prescribed, such as is given in ordinary fracture cases. The mouth was kept as clean as possible by means of a toothbrush and irrigation with a syringe after meals.

The skin sutures were removed on the 5th postoperative day and the intraoral ones 2 days later. The position of the jaw was checked by x-ray as soon as the patient's condition permitted. The findings were satisfactory and no further adjustments had to be made. However, a small sequestrum was located in the V-shaped opening at the right lower border of the mandible. A swelling appeared a few days later and a fistula opened in the incision. This was irrigated daily until two small pieces of bone were expelled, when the opening closed. The left side healed without complications.

The intermaxillary wires were removed after 6 weeks, when the mandibular splint

alone was sufficient to hold the lower jaw together. Eight weeks after the operation x-ray pictures were taken again and disclosed satisfactory union. The V-shaped space at the lower border had begun to fill in with bone, as shown in Figures 30 and 31. I therefore removed the attachments which were holding the fragments together, and when it was possible for the patient to eat without further discomfort the entire appliance was removed.

Examination 5 months after the operation showed satisfactory adjustment of the open bite (Figs 32 and 33). It is interesting to note that the second molar had drifted forward, partly closing the space created by the extraction. It can be expected that in a patient 18 or 19 years old this space will in time close completely, making room for the third molar to erupt and improving the posterior occlusion. Another set of x-ray films taken at this time, showed complete healing (Figs 34 and 35).

The end result was extremely satisfactory, the scars on the face were trivial and after recovery the patient was accepted for the Air Corps.

#### SUMMARY

The various methods devised in the past for correction of open bite are reviewed.

Open bite with angulation in the occlusal plane which may be due either to maldevelopment in the anterior part of the jaws or to faulty reduction of a fracture in the horizontal ramus of the mandible is best corrected within the dental arch.

A new method termed the V-shaped excision for the surgical correction of open bite in adults with little or no mandibular protrusion is presented. The method is especially useful in cases with angulation of the mandible in the premolar or molar region.

The method is an improvement on the V-shaped excision. The operation is performed from both an intraoral and an extraoral approach, and therefore requires more time than

the former procedure. This is justified however because it prevents injury to the alveolar nerve and vessels and gives a more accurate result.

#### REFERENCES

1. ANDER, E. H. *Dent. Cosmos*, 84, 40-43.
2. *Ideas. Treatment of Malocclusion of the Teeth and Fractures of the Maxillae*, 7th ed. p. 373. Philadelphia: S. S. Whit Dental Manufacturing Co., 1907.
3. BARNES, W. W. *J. Am. M. Ass.*, 1909, 53, 833.
4. BLAIR, I. P. *Surgery and Diseases of the Jaw*. St. Louis: C. V. Mosby Co., 1917.
5. BRENN, C. *Internat. J. Orthodont.*, 1917, 3, 69.
6. EISENBERG, E. *ort. Wien. klin. Wochschr.*, 1906, 18, 505.
7. HOLLISTER, S. P. *Am. J. M. Sc.*, 1919, p. 57.
8. KAWACHI, Y. H. *Internat. J. Orthodont.*, 1931, 7, 224.
9. KOTIK, P. *Vysch. Zakh.*, 1914, 40, 17.
10. KORTZ, F. *Internat. J. Orthodont.*, 1916, 20, 1079.
11. LANE, W. A. *Cleft Palate and Hard Lip*. London: The Medical Publishing Co., 1906.
12. LEWIS, A. *Dent. Cosmos*, 1915, 67, 9.
13. M. YAMAGATA. *Eyo d. Zakh.*, 1916, 3, 10.
14. NEW, G. B. and EATON, J. B. *Am. J. Surg.*, 1911, 21, 2.
15. PICKRELL, H. P. *Dent. Cosmos*, 1910, 54, 4.
16. SUTHERLAND, E. W. *Am. J. Orthodont.*, 1922, 8, 1.





Fig. 3.

Fig. 3. Case. Depicts expansion of the coronoid process and erosion of the zygomatic arch. In order to obtain this view it is necessary that the patient's head be partly



Fig. 4.

rotated and the rays directed tangentially to the side of the head. The exact amount of angulation can be estimated after the taking of scout films and fluoroscopic examinations of the head and face. This projection produces some distortion but does supply the maximum amount of detail.

Fig. 3. Case. Examination made with the patient in the apical position shows that the coronoid process has been removed and the zygomatic arch has been restored.

Fig. 4. Case. The posteroanterior projection shows lateral expansion of the coronoid process of the mandible and erosion of the inner surface of the zygomatic arch.

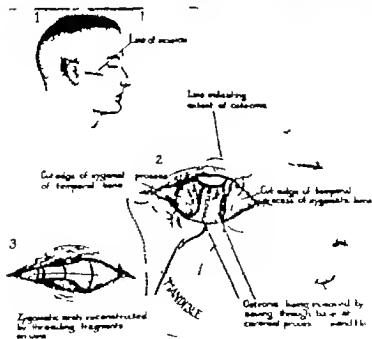


Fig. 5. Case. Steps in surgical removal of osteochondroma of coronoid process.



Fig. 6 Case 2 The special position graphically depicts the deformity of both the coronoid process and the zygomatic arch



Fig. 7 Case 2 Roentgenogram which was taken after operation, the coronoid process of the mandible has been resected

limiting membrane, and in time these cells produce the osteochondroma. The tumor characteristically has a stalk of normal appearing bone which terminates in a mushroom-shaped head that is capped with a layer of cartilage.

The tumors described in this paper were situated on top of the coronoid process, the site of insertion of the powerful temporal muscle. Except for this unusual location they were similar, pathologically and in rate of development, to osteochondromas found elsewhere.

The diagnosis of osteochondroma of the coronoid process is not easy. The true nature of the lesion in our first case was not recognized for several years, and it is probable that the second instance would have been missed also but for the experience with the first patient. The important points in diagnosis are slowly progressive, painless limitation of movement of the jaw in young persons, malocclusion in some cases, a bony hard swelling in the region of the zygoma, and the abnormal bony projection visualized by roentgenograms taken from the proper angle.<sup>1</sup>

Treatment consists of surgical removal of the growth. The operative procedure used in these 2 cases follows: nitrous oxide, oxygen, and ether were administered through an intranasal intratracheal tube. An incision was made over the full length of the zygoma, thus exposing the bone (Fig. 5). The periosteum was incised longitudinally and was raised with an elevator so as to uncover the entire bony arch. A Gigli saw was then passed subperiosteally around the bone, and the zygoma was cut across at its anterior attachment to the malar bone. In our first case it was possible to repeat this maneuver at the posterior end of the zygoma and to lift the resected bone out intact. In the second case this procedure was not possible because of impingement of the tumor, consequently, the zygoma had to be removed in several pieces with the help of bone cutter and rongeur forceps. In both cases the tumor was beautifully exposed by removal of the zygoma. It was then possible to cut across the pedicle of the osteochondroma with a Gigli saw and remove it, whereupon the jaw at once regained its normal mobility. In the first operation some of the protruding malar bone was rongeured away so as to lessen the original deformity of the

<sup>1</sup>Dr. J. W. Pierson was of great assistance in the roentgenographic studies.

cheek then the resected zygoma was replaced and fastened at each end with stainless steel wire passed through drill holes (Fig. 6). In the second operation in which the zygoma had been removed piece by piece the fragments of bone were strung like beads on a strand of stainless steel wire and were in this way fastened in approximately their old position (Figs. 5 and 7). The soft tissues were closed with interrupted fine silk sutures and the skin was approximated with horseshair. The wounds were dressed with vaseline gauze, dry gauze and a sea sponge for gentle pressure.

Each operation lasted about 3 hours, did not cause shock, and was not followed by any evidence of injury to the facial or trigeminal nerves, Stensen's duct, or oral mucous membranes. In both instances the patients were able to open the jaw freely the day after operation and masticated food with minimal discomfort. The temperatures by mouth did not exceed 100.4 degrees. Both wounds healed *per primam*; the sutures were removed on the 4th day after operation, and the patients were discharged on the 7th day.

#### SUMMARY AND CONCLUSIONS

Osteochondroma of the coronoid process of the mandible is believed to be rare. Two cases are presented in brief and the diagnosis and treatment are discussed. Although it is not wise to draw general conclusions from only 2 cases, certain clinical facts are worth noting.

- 1 Both patients were young males (ages 15 and 19 years).
- 2 There was no history of local injury.
- 3 Symptoms were slowly progressive over a period of years.
- 4 The leading symptom in both cases was painless, progressive loss of ability to open the jaw.
- 5 A late sign in both cases was increasing prominence of the zygoma of the affected side.
- 6 In each case routine examination by roentgenograms either did not show the tumor or else its true nature was not recognized.

#### REFERENCES

- 1 ELLIOTT, A. J. *Am. M. Ass.* 917, 68, 502.
- 2 GORDON, C. F. *Am. J. Roent.* 935, 34.
- 3 MAYNARD, H. W. *Radiology* 7, 8, 52.
- 4 RICHMOND, E. *Ann. Surg.* 99, 9, 673.

# MAMMARY CANCER IN YOUTH

TIBOR de CHOLNOKY, M D, F A C S, New York, New York

THE general impression prevails that the prognosis in carcinoma of the breast in young women is unfavorable as compared to that in older patients. This impression is supported by the available literature. For example, Ewing states in his authoritative book, *Neoplastic Diseases* (1940) "Before 30 years of age mammary cancer is extremely fatal so that some surgeons prefer not to operate during this period." A survey of our own material at the tumor clinic of the New York Post-Graduate Hospital, indicated that, with proper radical surgical treatment, the outcome in breast cancer in young women is as favorable as in older patients.

Realizing that our own material was meager, we gained the co-operation of the surgical staffs of the Roosevelt Hospital, the New York Hospital, and the Lenox Hill Hospital in New York City, and the Pondville Memorial Hospital and the Massachusetts General Hospital in Boston. This enabled us to review 73 cases of mammary cancer in patients under 30 years of age.

Although this survey includes a relatively small number of cases, it is based on a larger group of cases than the reports of those who have postulated an unfavorable prognosis in this age group.

## INCIDENCE OF BREAST CANCER AND AGE DISTRIBUTION IN PATIENTS UNDER THIRTY

Reviews (2) show that cancer of the breast is almost unknown in childhood and youth, and is rare in young adults.

Vital statistics<sup>1</sup> for 1930-1939 give the figures as shown in Table I, for deaths from cancer of the breast by color, sex, and ages in the United States.

Cancer of the breast in patients under 30 is more common among negroes than whites—the

ratio is 2:1 in males and 3:1 in females which may be due to earlier maturity.

Table II indicates deaths from cancer of the breast in patients under 30 years of age.

Further statistical study reveals that of every 1000 cases of cancer of the male breast in the white race, 10 patients are under 30 years of age, of every 1000 cases of cancer of the breast in the white female, only 6 are under 30 years of age.

On the basis of collected clinical material, it appears that cancer of the breast in patients under 30 constitutes 2 per cent of all breast cancers, while those under 20 constitutes 0.09 per cent of the total.

The earliest available report of a case of breast cancer in the young was published in 1851 by Cooper. The youngest noted in the literature was 10 years old, which Sears diagnosed as adenocarcinoma grade II, the other a patient 11 years old, Thompson also diagnosed as adenocarcinoma. Other examples of breast cancer among those under 20 include 2 patients aged 12 (Blodgett, Levings), 1 aged 13 (Luttinger), 1 aged 14 (Carnett), 3 aged 15 (Chauvel, Nunn, Power, 16), 1 aged 16 (Harrington, 15), 3 aged 17 (Harrington, 15, Winslow and Heitzmann), and 1 aged 18 (Kaufmann). There was a 12 year old boy in this group (Blodgett) and another 15 years of age (Bryant). The rarity of cancer in patients under 20 years can be appreciated by the fact that in the available literature only 18 reports were found.

The age incidence in our combined series is as follows: aged 12 years, 1, 15 years, 1, 18 years, 1, 21 years, 2, 22 years, 2, 23 years, 6, 24 years, 1, 25 years, 8, 26 years, 9, 27 years, 9, 28 years, 14, 29 years, 19. The ages noted were those given on the charts at the time patients were admitted to the hospital for treatment, although from the histories it was evident that the disease had started earlier. If age 30 had been included, the

TABLE I—DEATH FROM CANCER

	All ages	Under 30	Percentage
Males			
White	1361	14	1.0
Colored	134	3	2.2
Females			
White	113,415	751	0.6
Colored	7094	162	2.2
Total	122,004	930	0.7

From the Tumor Clinic Department of Surgery, New York Post-Graduate Medical School and Hospital, Columbia University.

<sup>1</sup>U. S. Bureau of Census. Vital Statistics—Special Reports Mortality Statistics.

TABLE II—DEATHS FROM BREAST CANCER IN PATIENTS LESS THAN 30 YEARS OF AGE

Age	Population	Deaths	Rate per 100,000	Per cent of all cancer
0 to 4	10,833,222	2	0.02	0.02
5 to 14	23,347,523	3	0.01	0.03
15 to 24	21,235,387	21	0.10	0.20
25 to 34	18,017,199	290	1.61	2.68





Fig. 9. Rapidly growing diffuse duct cancer complicating lactation of 4 months duration. Enlargement of the breast as noted in the 26 year old woman 1 month after childbirth. Patient died of general metastases after 7 months of illness.

number of cases would have been increased by 30 per cent.

Whereas in this group more than one half applied for surgical consultation in our general series of cases of cancer of the breast (Eggers, de Cholnoy and Jessup) only one third applied for surgical consultation within the first 6 months. This may indicate more alertness in young women, or results of public education.

#### SYMPTOMATOLOGY

Chief complaint was the same as in adult cases—the discovery of a “painless lump.”

Clinical examination in the early cases did not reveal signs of malignant neoplasm. Frequently the tumor was freely movable (10 per cent) and a diagnosis of fibroadenoma was made. It was only by means of frozen section at operation or by routine pathological examinations that the diagnosis was established.

When the tumor was hard, its border ill defined and there was some fixation to surrounding tissues cancer was suspected.

Early diagnosis and treatment may be facilitated if the surgeon's policy is to remove all solid tumors regardless of signs of cancer and to proceed with the radical operation if the findings are substantiated by microscopic examination.

Fixation to the overlying skin, dimpling and retraction of the nipple with elevation and deformity of the breast, as well as axillary lymph node involvement are signs of advanced malignant tumor.

Careful examination in the sitting as well as in the lying position should be done with the arm in

different positions, to facilitate palpation. Inasmuch as the majority of breast tumors are situated in the outer upper quadrant their detection and study of detail is favored when the patient is placed on the normal side and the suspected breast allowed to drop over that side. When the examining palm is pressed against the chest wall and the breast is gently palpated, a growth becomes more prominent, may even become visible, and the dimpling of the skin is more evident.

#### DIFFERENTIAL DIAGNOSIS

In young women inflammatory lesions are observed most frequently especially in connection with nursing. Some intraglandular abscesses with infiltration may simulate cancer but tenderness, edema, and the course of the inflammatory process aid in differentiation.

Tuberculosis of the breast may simulate cancer especially if there is axillary lymph node involvement. The softer consistency of the axillary lesion, which has the tendency to adhere early to the skin to form fistula favors the diagnosis of tuberculosis rather than cancer. A pathological examination will be conclusive. X-ray films may show the origin of the tuberculous lesion in the chest.

Syphilis and coccidiomycosis are rare conditions but are occasionally encountered in the breast.

We pointed out in previous papers (9, 10) that fibroadenoma predominates in females and males under 30 years of age. In the male the fibroadenoma is a diffuse nonencapsulated lesion, and may be mistaken for cancer (10). Multiple tumors suggest benign lesions, such as fibroadenomas or cystic disease of the breast, but do not necessarily exclude the possibility of the presence of a cancerous nodule. Paraphimosis of the breast may be mistaken for cancer (11). A hard, firm nodule especially affixed to the surrounding tissue calls for excision and pathological examination.

#### SITE

In our series, cancer occurred more often in the right breast. In both breasts, the tumor seems to have been more frequently observed at the outer upper quadrant.

#### SIZE OF TUMOR AND AXILLARY LYMPH NODE INVOLVEMENT

The size of the tumor varied from 0.5 to 17 centimeters in diameter. Among 3 lesions there were 8 small tumors (up to 3 cm. in diameter), 11 medium sized ones (3 to 4 cm. in diameter) and 11 large ones (4 cm. and over).

TABLE III — RESULTS\*

Hospital	Total	Inoperable	Operated Upon					
			Less than 5 years		More than 5 years		More than 10 years	
			Alive	Dead	Alive	Dead	Alive	Dead
Skin and Cancer Unit Post Graduate 1925-1930	17	6	4		3	4	1	1
Lenox Hill 10-4-1930	11	1			4	0	1	
New York 193-1930	6				1	3		
Roosevelt 1910-1930	15		1		5	10	3	5
Pondville Memorial and Massachusetts General 19-1930	1	5	1		7†	0	1	4
Total	5	14*	10		20	0	6	10
Per cent					40	0	16	
					40	0	37	

Drs. William De W. Andrus, Walter W. Brandes, William A. Cooper, Henry W. Cline, Carl Eggers, Thomas H. Russell, Grantley W. Taylor, and William C. White were most kind in facilitating the review of the material from the hospitals with which they are connected. Miss Elizabeth Carr, librarian of the New York Post Graduate Hospital, and P. R. Eastman of the Metropolitan Life Insurance Company, furnished the statistical data.

\*One alive with disease after supraclavicular node dissection.  
†Including 3 recurrences after insufficient operation performed elsewhere.

It is interesting to note that only 1 instance of axillary lymph node involvement was found among patients with small tumors. On the other hand, in patients with tumors over 3 centimeters in diameter in whom radical operation was performed, axillary lymph node involvement was demonstrated in 90 per cent. This corresponds with observations made in adult cases (12).

Seven of the 8 patients with small tumors survived the 5 year period.

Of 11 patients with cancer of the breast without lymph node involvement, operation resulted in 5 year arrest in 10 cases (90 per cent with 1 death), while only 5 of 25 cases with lymph node involvement survived the 5 year period (20 per cent), with 20 deaths.

Lymph node involvement was found in 58.5 per cent, which is somewhat better than the 63.7 per cent found among our general series of cancer of the breast (12). This observation corroborates Harrington's findings, who reported axillary involvement in only 48.5 per cent, contrasting with 61.6 per cent in the older groups.

#### PATHOLOGY

In 45 of the cases, grading of the tumor was obtained. In 8 cases the tumors were found to be



Fig. 2. M. J., 26 years of age. A typical postoperative result 4 years after radical amputation of the breast for cancer. No swelling of the arm and good functional result.

grade 3 or grade 4. All of these patients, showing a very active growth, died within 1 year after operation, except 1 who is still alive after 5 years on whom radical operation was performed.

The following pathological diagnoses were noted: 2 grade 1 adenocarcinoma, 1 papillary cystadenocarcinoma (with axillary involvement and inoperable), 16 adenocarcinoma grade 2, 4 colloid carcinoma, 2 medullary carcinoma, 3 carcinoma arising in fibroadenoma, 1 solid carcinoma, and 2 inflammatory carcinoma. In 11 the only diagnosis was carcinoma of the breast.

Among those surviving the 5 year period the diagnoses were: 5 adenocarcinoma, 1 duct carcinoma, 1 colloid carcinoma, 2 medullary carcinoma, 2 carcinoma in fibroadenoma. In the remainder the carcinoma was not classified. There was 1 male of 25 with colloid carcinoma who died within 2 years. A bilateral colloid carcinoma in a 22 year old woman ended fatally within a year.

In this younger age group late metastasis may be observed, as in the general group. Pulmonary metastasis was noted in a 21 year old girl, 5 years after removal of the breast for cancer, indicating late permeation of the lung (Boyd). One of our patients, a 28 year old woman, died 7 years after a radical operation had been performed, with general metastasis.

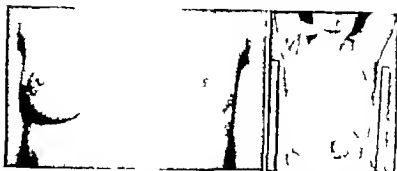


Fig. 3. A. L. N. D670, 4 years of age. Bilateral cancer of breast. Extensive involvement of left breast with axillary metastasis necessitating its excision and plastic repair by an abdominal skin flap and skin grafting on the right. Good functional result. Final outcome after 3 1/2 years. No local recurrence.

Cancer of the breast in a girl of 17 was observed in an accessory breast (Hentzmann). This is a rare occurrence but it may be that such a tumor develops in the prolongation of the glandular element with direct connection with the main breast tissue (8). There were no patients with bleeding or discharging nipple and there were no patients with Paget's disease in this series.

#### TREATMENT

We believe that punch biopsy is unsatisfactory and dangerous in inexperienced hands. If operation is performed for biopsy purpose, the whole tumor should be excised for examination. Once the diagnosis of cancer is definitely established radical operation should be performed with careful and thorough axillary lymph node dissection as described in a previous paper (9).

In 3 cases in this series, extensive operations were performed to give relief to the patient. One 22 year old girl had a bilateral advanced cancer. We gained the impression that in spite of painstaking radical operations, life could not be prolonged materially.

There were 13 (7 per cent) inoperable cases. Five of them were recurrent lesions, with distant internal metastasis, in patients who had undergone previous excision or simple mastectomy. In these patients no operation was performed for palliation. There were cases of inflammatory malignant tumor at the age of 16, with rapid fatal outcome.

No definite improvement was noted following x-ray therapy which however may be tried in patients with rapid growths.

#### RESULTS

A detailed analysis of Table III shows the number of cases and the results at the different

hospitals. Cases lost or not followed up (18) are classified as died from disease. There was no operative mortality.

Of the 73 collected cases, 14 (19 per cent) were inoperable at the time of admission. Forty nine were operated upon more than 5 years previous to this study. Of these, 20 were alive constituting a 40.8 per cent 5 year result. Of 16 patients operated upon 5 years previously 6 were alive a 37 per cent 10 year result.

These figures in this small group indicate that in young women late recurrences are less frequently observed.

#### BILATERAL CANCER

Cancer in both breasts may be noted simultaneously (10) or the malignant neoplasm may appear in the second breast after an interval of months or years.

Bilateral cancer developed in 5 per cent of our series, which corresponds to the findings in our general series (12). One of these patients lived over 5 years.

A brief outline of their histories follows:

CASE A. A 17 year old married woman came to our clinic with diffuse advanced cancer of the breast with axillary lymphatic nodular and skin metastases (Fig. 3). She stated that in another hospital she had had consultation 5 months previously and received "injections." Information was obtained that the patient, as treated by thoracic injections for diffuse neoplasia. I suspect that early diagnosis was not made or that the administration of radioactive substances may have had some influence in the development of cancer. I opted for radical operation, consisting of removal of the right breast with plastic repair 5 months later the removal of the left breast and axillary-lymphatic nodular lymph nodes, the patient died with general metastases 10 months later.

CASE B. A 16 year old girl had had radical operation for cancer of left breast with axillary lymph node involvement, by Dr. Robert H. Kennedy 1 1/2 years later patient had been delivered of normal child, and 3 years after this

cancer was found in the other breast. A radical operation was performed by Dr. Richard Kessler. A therapeutic abortion was performed within a year. Two years later a local recurrence was excised in the right axilla. This patient is now alive 11 years after the first operation, completing the 5 year survival period after the second breast operation (Fig. 4).

CASE 3. A 20 year old woman, in whom both axillae were extensively involved, came for treatment. She gave the history that 3 years previously both breasts had been removed for "benign tumors" and no lymph nodes were dissected.

CASE 4. A 28 year old patient died 9 months after bilateral radical mastectomy (performed within 2 months) for an advanced grade 3 cancer. This patient was one of 7 children, 4 of whom have, so far, had cancer.

#### PREGNANCY AND LACTATION

Four of this series living over 5 years, gave the history of pregnancy. Three were delivered of a normal child before or after the radical operations and nursed their babies for 3 to 6 months. One had insufficient milk from the breast. One of our patients is alive 11 years and 5 years, respectively, after bilateral radical operation (Fig. 4). She had 1 child between the 2 radical operations and had an abortion after the second breast was removed.

This observation is insufficient for any conclusion, and the reader is referred to Harrington's (16) remarkable work on the subject. From his observation the prognosis appears to be unfavorable if the malignant neoplasm develops during the childbearing period and there is axillary lymph node involvement, but a high survival rate was found with early radical operation, especially when the cancer was not of high grade and no axillary lymph node metastasis was found.

It is gratifying to know that if pregnancy occurs after radical operation, young women may deliver healthy children and because of childbearing may not develop generalized metastases. If the tumor is a small early growth, without lymph node involvement, and if patient remains well for about 3 to 5 years, one may permit pregnancy. But with advanced growth and axillary involvement the prognosis is known to be poor, in such cases recurrence and distant metastasis are common, and birth control should therefore be considered.

#### ANALYSIS OF STUDY

This study reveals that cancer in the young occurs more frequently than previously thought. Unfortunately the early lesions are frequently not diagnosed because malignant tumor is not suspected and physical signs are not convincing. Thus, the safe way to avoid errors is to remove all solid tumors of the breast, for the danger is that the harmless fibrous tumor may be malignant.



Fig. 4. I. D. No. J38247. Result after bilateral radical operation for cancer of the breasts. Left breast was amputated 11 years ago at the age of 23 years by Dr. Robert H. Kennedy. Axillary lymph nodes were found involved by cancer. Right breast was amputated 5 years ago, by Dr. Richard Kessler. Local recurrence in the right axilla was removed 3 years ago. Patient has no evidence of local or general metastasis at the time of writing.

One of our patients, a 27 year old girl had been advised by 3 physicians not to worry, about a small "lump" and had been given x-ray therapy to dissolve the growth. When she applied for treatment she had a far advanced cancer of the breast. Such a conservative attitude is not a unique observation and it may account for the pessimistic prognosis previously held. The number of inoperable cases (17 per cent) is extremely high, and may be the result of neglect or inadequate surgery, or even massage of the lumps which may have promoted internal metastasis. In case of multiple solid tumors, the removal and examination of one does not assure diagnosis, for one of the tumors remaining may be malignant, as it was found to be true in a previously reported case (9).

Painstaking radical operation prolongs life or saves patients with axillary involvement, and the local recurrence rate is very low.

#### SUMMARY

This study is based on 73 cases of mammary cancer in patients under 30 years of age, collected from the records of 6 hospitals, the careful follow-up records, it is thought, make this study more valuable. Cancer of the breast in patients under 30 years of age accounts for 2 per cent of all mammary cancers. Early diagnosis can be made with certainty only in the laboratory. In small

tumors less than 2 centimeters in diameter lymph nodes are infrequently involved and the prognosis is favorable.

Five year survivals in the patients operated upon were found to be 40.8 per cent 10 year survivals, 37 per cent.

The conclusion is reached that the results of radical surgery in young women under 30 years of age are comparable to those obtained in the more advanced age groups. The previously held belief that the prognosis for women under 30 years of age who have malignant tumors of the breast is fatal seems untenable.

#### REFERENCES

- BLUMBERT, A. N. Boston M & S J 89 366
- BOGERT, E. Am. J. Pub Health, 934, 5 245 50.
- 8 BORN, WILLIAM. Surgical Pathology 4th ed. Philadelphia W. B. Saunders, 916.
- 4 BRANT, R. C. Surg Gyn. Obst. 9 4, 2 545-546.
- 5 CANNETT, J. B. and WILSON, B. P. and HOWELL, J. C. Surg. Clin. N. America, 933, 363
- 6 CHARTER, and REED, M. Bull. Soc. natl. Paris, 92 9 45.
- 7 COOPER, B. R. Lectures on the Principles and Practice of Surgery London J. Churchill, 5
- 8 DE CROMBIE, T. Brit. Arch. Surg., 939, 30 924-44
- 9 Ibid. 940, 35 70-98.
- a. Idem. Am. J. Surg. 935, 30 294-304
- Idem. 936, 41 640-653.
- EDGERS, CURT, CHOLSO, T. and J. W. D. S. D. Am. Surg. 94 3 32 440
- 3 ELLIOT, J. Neoplastic Diseases 4th ed. Philadelphia W. B. Saunders, 940
- 14 FOWLER, R. H. Med. Rec. N. Y. 5, 87-730-732
- 5 HARRINGTON, S. W. Personal Ann. M. J. 94-45 4 5 437
6. Idem. T. Am. Surg. Ass. 17 55 200-0
- 7 HERTZ, C. Med. Rec., 244, 34
- 8 KATZ, A. E. Pathology Philadelphia H. K. Lippincott 930 Vol. 2.
- 9 KATZ, L. W. and KATZ, B. S. Am. J. Surg., 934 77
- 10 LINTON, A. H. Am. J. Surg. 9 3 29-32.
- LEITCH, P. Cancer 944, 27 13
- NEW, L. L. Northwest M. 937, 30 30
- 3 RICE, J. B. and SCHLESINGER, M. J. N. England J. M. 940, 1 700
- 14 T. LOR, G. W. Personal communication.
- 5 TURNER, H. U. Brit. M. J. 938 90
- 16 WILSON, R. Ann. Surg. 92 4 34 344

# THE EVOLUTION OF THE CIRCULATION IN THE DEVELOPING FEMORAL HEAD AND NECK

## An Anatomic Study

W. EUGENE WOLCOTT, M.D., F.A.C.S., Green Bay, Wisconsin

THREE years ago a report<sup>1</sup> was made of a study of the circulation in the adult femoral head and neck. The most significant observations made at that time may be briefly stated as follows:

1. The ligamentum teres carries at least one main artery which penetrates the head of the femur and anastomoses with vessels entering the head by way of the visceral capsule in approximately 80 per cent of the specimens successfully injected, even in those of the most advanced age.

2. In approximately 50 per cent of the adult specimens in which the ligamentum teres arteries were successfully injected, the vessel failed entirely to enter the femoral head. In these instances the opaque material could be seen to course through the arteries of the ligament to the lower area where it was then returned through the veins of the ligament away from that area.

3. The uniformity of size and area of distribution of the vessels within the femoral head led to the conclusion that it was adequate to nourish a greater portion of the head of the femur in all cases in which the artery actually penetrated the substance of the head.

4. It was likewise noted that the visceral capsule never failed to carry two groups of arteries—usually three to four in number—which uniformly entered the neck of the femur just distal to the subscapular area. Immediately after entering the neck of the femur these vessels change their course at a 45 degree angle and travel directly toward the center of the femoral head where they anastomose freely with the terminal branches of the nutrient artery of the shaft and the ligamentum teres vessels sending their terminal branches to the subcondylar area about the circumference of the head. These two capsular artery groups lie within the superior posterior quadrant and inferior posterior quadrant of the visceral capsule, which is loosely attached to the neck of the femur. No arteries of importance were found within the anterior portion of the visceral capsule. These capsular arteries which were found to be the never failing and major source of blood going to the head and neck of the femur arise from the

medial circumflex artery—a branch of the femoral profunda—which lies close to the bone in the intertrochanteric line behind.

5. It was likewise found that a small branch from the posterior circumflex artery joins with a branch of the obturator just distal to the cotyloid notch to make up the blood vessel which passes under the annular ligament and sends one of its terminal branches into the ligamentum teres, the other passing on to supply the pulvinae fat pad in the floor of the acetabulum.

6. Finally we were interested to observe that we always failed both by injection or opaque material and serial sections to demonstrate blood vessels entering the substance of the femoral head by way of the ligamentum teres in specimens from infants and children under approximately 10 years of age. It was this last significant observation which prompted a further study of the literature and investigations concerning the circulation in the developing femoral head in the preadolescent age group which furnishes the material upon which this report is founded.

As a result of an exhaustive review of the literature available on this subject, one seems justified in saying that such a study tends to confuse rather than clarify our thinking. Obviously a better knowledge of the circulation as it develops in the femoral head and neck of the growing child would be expected to add to our understanding of the sequence of events associated with certain of those conditions which are frequently seen affecting the hip joints of children and which are so difficult to explain in the light of present knowledge.

### REVIEW OF LITERATURE

Hartle, as early as 1846, announced that he had shown by injection that the ligamentum teres vessels in children failed to enter the spongy bone but anastomosed through capillaries with the venous system without entering the femoral head.

Since that time, and even before, opinions of different authors on the importance of these vessels for the nutrition of the growing femoral head have been very controversial and discrepant.

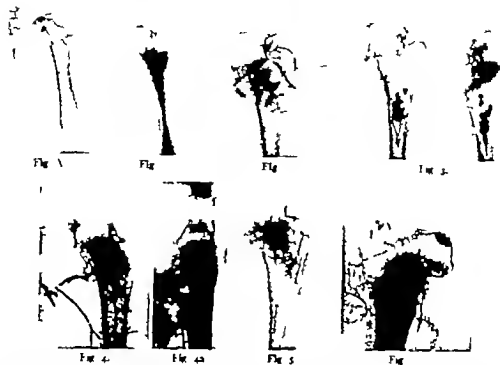


Fig. 1. Femur of 5 weeks old pup. Injected cap-sular arteries of the femoral neck demonstrated as being distributed to the ossifying center of the developing head of the femur.

Fig. 2. The femur of an 8 month old fetus as injected by way of the nutrient artery of the shaft only. The injected material has found its way into the capsular arteries shown at the base of the neck of the femur. This specimen demonstrates the presence of an anastomosis between the nutrient and capsular arteries being established even before birth.

Fig. 3. The medial circumflex artery only as injected in specimen of an infant only 6 weeks old, demonstrating an early penetration of the capsular arteries into the cartilaginous head of the femur.

Fig. 4. Specimen from 6 weeks old infant. Injection of the medial circumflex ligamentum teres and nutrient vessels were made. Although none of the injections as entirely satisfactory, the opaque material in small amounts reached the capsular arteries back are clearly demonstrated to be entering the substance of the head of the femur, one branch penetrating nearly to the nuclear area of the head.

Fig. 5. Femur from an infant 4 months of age. The medial circumflex artery as injected. The inferior

capsular arteries can be seen to penetrate into the osseous center and developing head of the femur.

Fig. 6. The lateral view of Figure 4 demonstrates the extent to which the capsular arteries supply the growing center of the femoral head at 4 months of age.

Fig. 7. From the femur of a boy 3 years old. Nutrient artery of shaft only injected. The anastomosis of nutrient artery of the shaft and capsular arteries of femoral neck is shown. Capsular arteries of the neck not injected directly.

Fig. 8. Specimen from an infant 6 months of age. The capsular arteries are best directly injected here they branch from the medial circumflex artery. Later the nutrient artery of the shaft as successfully injected but failed in an attempt to inject the ligamentum teres artery.

This injected specimen demonstrates very clearly and positively the patterns of distribution of the arteries back contribute blood to the nuclear ossifying center of the head and neck of the femur as early as 6 months of age.

It is apparent that the very small arteries back travel the length of the ligamentum teres supply anastomosis to the foetal and shallow adjacent area of the head of the femur. This specimen also serves to present convincing evidence that no end branches of the nutrient arteries penetrate the epiphyseal plate area 6 months of age.

Palletta in 1830 and Sappey in 1844 thought the vessels of the round ligament played an important part in the nutrition of the developing femoral head. Hence was of the opinion that vessels of the round ligament, in case of detachment of the head, were able not only to maintain the normal nutrition of the nucleus of ossification of the

head of the femur but also by forming granulation tissue to vascularize the joint cartilage. Nussbaum injected opaque dyes into the round ligament vessels and always found them entering the head of the femur.

Kolodny too by the injection method reported he was able to demonstrate that the central region



Fig 7



Fig 7a



Fig 8



Fig 8a

Fig 7 The specimen is from the femur of a boy 7 years of age. The injections were made successively in the nutrient artery of the shaft both the superior and inferior capsular arteries, and the ligamentum teres arteries. The injected specimen submitted shows a very extensive blood supply already established throughout the head and neck of the femur. Also the capsular arteries are demonstrated to be the most direct and important source of nourishment to the ossifying center in the head of the femur. Fine end arteries or terminal branches of these arteries can be seen to penetrate to the very periphery of the expanding ossifying portion of the femoral head. Some of these minute vessels have given way under the pressure exerted on the opaque fluid, during injection, as can be seen by the collection of lakes of the material in the subcondylar area about the periphery of the head of the femur.

of the femoral head was directly entered by vessels of the round ligament after they had penetrated the head at the fovea capitalis. Mazzarella reported that the head of the femur in the newborn was nourished by the artery of the round ligament as well as branches from the capsular arteries. After the second year of life, the time of establishment of the epiphyseal cartilage and appearance of the center of ossification in the femoral head. He also agreed with Lever and Langer that the head is also supplied with blood from anterior branches from the neck which pass through the epiphyseal cartilage, but these last vessels are of little importance in his opinion. Schmorl expressed the idea that as early as the second year of life, the ligamentum teres vessels begin to obliterate by proliferation and swelling and atrophy of parts of the vessel wall. This was regarded by him as physiologic obliteration, inactivity atrophy. It was also his belief that from the second year until the third decade of life there was no great change in the condition of the ligamentum teres. After the third decade of life, the lumen of the vessels becomes narrow, showing only a narrow slit or one entirely impermeable.

Also in this lateral view, one notices a few end artery branches of the injected nutrient artery passing through thinned out portions of the dome of the epiphyseal plate.

Fig 7a Lateral view of the same specimen as in Figure 7. Here we see again the tremendous fine network of arteries distributed to all portions of the femoral head as the ossifying center expands. However, the significant fact to be noted is that in this view contact has not been made between the capsular arteries and those of the ligamentum teres.

Fig 8 Specimen from a 10 year old girl. Ligamentum teres and nutrient artery injection. Branches from nutrient vessels seem to penetrate the epiphyseal plate and terminate in the ossifying nucleus. The material injected by way of the ligamentum teres vessels failed to enter the head.

These processes were thought by him to be physiologic involution after the end of the growing period. After the fifth decade of life the changes of the vessels are usually pathologic. There is, therefore, a continuous decrease of blood flowing to the head of the femur after the second year of life, until changes in the ligamentum teres make the blood circulation impossible. It is obvious then that Schmorl is of the opinion that the ligamentum teres vessels are of importance in nourishing the growing head of the femur before the second year of life.

Luschka in 1865 stated that he never failed to find arteries which made their way through pores of the fovea capitalis into the substance of the head of the femur. Logrosino, after injecting dyes into the round ligament arteries, found good development and distribution of the branches of these arteries in a triangular district in both youths and adults. Elgart compared the round ligament to the umbilical cord whose vessels obliterate after losing their function. Devermann, Langer, Eggers, Cooper, Bonnet, Moser, Hildebrand, and Anschuetz are other authors who attribute importance for the nutrition of the head





Fig. 9. Specimen from 9 year old boy. The only vessel injected are the capular arteries at the base of the femoral neck. During the injection, the opaque material could be seen to drop out through the ligamentum teres vessels, demonstrating completion of the anastomoses between the ligamentum teres, the capular and femoral vessels. All portions of the shaft, neck and head of the femur are seen to be well supplied with blood vessels.

of the femur only to the round ligament vessels of juvenile individuals they have only a secondary and undetermined importance after termination of bone growth in the head of the femur.

Zemansky apparently accepted the opinions of the authors mentioned for he stated, "Thus, anatomical studies have definitely established that in the adolescent the femoral head is nourished by the round ligament vessels. He subsequently did a series of arterial injections, using rabbits, according to the method of Gross, demonstrating to his own satisfaction that the vascular arrangement was not dissimilar to that of the human femur at corresponding age. After injecting series of rabbits of different age groups, he concluded that the blood supply from the ligamentum teres vessels to the femoral head gradually diminishes and ceases completely when the epiphysis unites with the shaft. It cannot be stated with certainty that the round ligament vessels of the human cease to furnish blood to the femur at the same relative developmental stage. However inasmuch as all anatomical evidence indicates that these vessels usually are completely closed in human adult life it is most likely that similar condition exists."

Chandler after studying serial sections of femoral head and ligamentum teres in 20 fetal specimens 1 month to 1 term, reported that

vessels are present long before the seventh month. As soon as the vessels of the round ligament enter the head they branch and continue to penetrate into the substance of the bone. He further stated that a union is present between the vessels of the round ligament and the capsular or metaphyseal arteries in adult life but such union has not occurred in the specimens available for his study. He failed to express an opinion as to when anastomoses of these two systems took place beyond saying such union probably occurs some time after birth. Thus, we have an extensive group of investigators who believe that the ligamentum teres vessels uniformly enter the substance of the head of the femur in infants and growing children and are at least chief if not its only source of blood supply during all or a major portion of the growth period.

#### VISCERAL CAPSULAR VESSELS

A second group of investigators, after anatomical studies are of the opinion that the capsular arteries entering the femoral neck near the epiphyseal plate, not the ligamentum teres vessels are the true source of nourishment to the growing femoral head. As previously mentioned Hyatt observed vessels in the round ligament but concluded that they anastomosed with one of the junctions of the ligament with the head and then passed back through the ligament. He further

stated it was his opinion that the epiphyseal nucleus in the femoral head of growing children received its blood supply from the capsular vessels of the neck. Walmsley in 1915 studied the ligamentum teres in cross section by aid of a hand lens and also by injection methods. He reported that "the ligamentum teres does not convey blood into the head of the femur. Most of the foramina in the fovea capitalis are channels of communication of the ligamentous tissue into the cartilage of the fovea and osseous substance of the bone, not vascular openings." Chandler in 1936 reported as his opinion that the "head of the femur, before fusion of the epiphyses, received its blood supply through the branches of the cervical vessels which lie in the folds of reflected synovia along the femoral neck and from the vessels of the ligamentum teres. After fusion of the epiphysis at the conclusion of growth, small vessels of the femoral neck anastomose with those of the femoral head."

#### ANIMAL EXPERIMENTATION

Several investigators have done animal experiments using cats, dogs and rabbits to conduct studies of the effect produced on growing femoral heads by interrupting the various blood supplies to the upper end of the femur. In this group the work of Cella in 1936 is especially interesting. He used cats, dogs, and rabbits of different ages. In the first group resections of the round ligaments were done at one day of age, before the formation of the nucleus of ossification. The specimens were recovered after the growth period. In this group there were no microscopic changes in the head of the femur. Microscopically, there was a small zone, corresponding to the insertion of the round ligament, having poor staining ability, the cells with small nuclei. The center of ossification appeared always normal. The second group of animals operated upon 10 days after birth produced the same macroscopic and microscopic changes as were observed in the first group, but they were more pronounced. There was produced an ischemic triangular zone with the base at the implantation of the round ligament, reaching down to the center of ossification. The cells in this area contained small nuclei and granulous protoplasm. The nucleus of ossification appeared normal always and did not show any defect of osteogenesis. In the third group of 40 day old animals at 5 months and in old animals, no macroscopic or microscopic changes followed division of the ligamentum teres. The conclusions as stated by Cella are

1 The round ligament carries vessels which contribute to, but are not indispensable for, the

development of the osseous district which corresponds to the implantation of the round ligament. They play a rôle only in the young animals (rabbits and cats) previous to the formation of the nucleus of ossification, especially during the first moments of its formation.

2 The importance of these vessels diminished rapidly with increasing age of the animals and even immediately after the formation of the center of ossification there occurs no change in the head of the femur after elimination of these vessels, except in a small zone around the implantation of the round ligament.

3 The nucleus of ossification of the head of the femur obtains its blood supply from branches of the posterior circumflex artery. The vessels of the round ligament have no importance whatsoever in its nutrition. Our own experience in experimental work on young dogs is identical with that of Cella. After the division of the ligamentum teres, the femoral heads reclaimed at the end of 30 and 60 days showed no change when compared with the control head, except for a slight depression of flattening about the insertion of the ligamentum teres. We were also able to prove to our own satisfaction that the capsular arteries, even at the 5th week, send very definite vessels into the ossifying center. The circulation pattern of these vessels was easily demonstrated by the injection method (Fig A). Obviously these findings offer a logical explanation of the absence of changes in the ossifying center following the division of ligamentum teres in experimental animals.

Iselin who conducted similar experiments on young dogs, and Bergmann who worked on young rabbits, reported like findings. Stewart, after extensive investigations on young dogs, reported "no marked changes occurred in the animals in which the ligamentum teres alone was cut."

In view of the fact that uniformly when the ligamentum teres in young animals is divided, no gross changes occur in the ossified center of the head of the femur, we believed we were justified in taking sides in this controversy with those who were of the opinion that the capsular vessels, not the ligamentum teres vessels, furnish nourishment to the growth center in the head of the femur. To add further proof that such was the case, we decided to make an attempt, by the injection method, to demonstrate the circulation pattern of the capsular and nutrient arteries at various age levels, beginning with fetal life and carrying on into the adolescent years when we were quite certain that these circulations

finally broke through and established an anastomosis with the round ligament vessels. Fresh autopsy material was secured and the vessels were immediately injected with opaque material under twelve power binoculars. We used a specially constructed thirty gauge needle and a one cubic centimeter syringe. X-ray films were taken to demonstrate the course of the blood vessels. A group of specimens have been selected from the accumulated material varying as to age groups from the 8th month of fetal life to 15 years of age. This material is now presented in the hope we will be able to show satisfactory evidence that

1 The nutrient artery of the shaft establishes communication and definitely anastomoses with the capsular arteries very early even in fetal life.

2 The capsular arteries very early in life push several sizeable blood vessels through the cartilage at the junction of the head and neck, which vessels, however go around the epiphyseal line by-passing that cartilage, so to speak, and as soon as they enter the cartilaginous substance of the femoral head, angulate at 45 degrees and travel directly to the ossifying center. Doubtless both the posterior superior and posterior inferior capsular arteries send branches to the growth center. However we have not been able to demonstrate both as contributors in every instance.

3 The capsular arteries are the only essential source of blood supply to the ossifying center in the head of the femur. We failed in all our attempts to demonstrate injected material entering the substance of the head of the femur in infants and children by way of the ligamentum teres vessels, although we were able successfully to force the opaque material through these vessels to the fovea.

4 The anastomosis between the capsular arteries and the ligamentum teres vessels does not take place until the ossifying center of the head is expanded to the point where only thin articular cartilage separates the capsular and ligamentum teres vessels at the fovea. As the cartilage in this area thins out, the contact between these two systems occurs and anastomosis is accomplished perhaps to approximately the 13th to 14th year of life. Failure for any reason to establish this anastomosis accounts for the 20 per cent of adults in whom the ligamentum teres vessels fail to enter the head.

#### DEMONSTRATION OF INJECTED SPECIMENS

In Figure 1 is presented the femur of an 8 month old fetus which was injected by way of the nutrient artery of the shaft only. It is seen that the injected material has found its way into the

capsular arteries shown at the base of the neck of the femur. This specimen demonstrates the fact that an anastomosis is present between the nutrient and capsular arteries and was established even before birth.

In Figure 2 a specimen of an infant only 6 weeks old, the medial circumflex artery only was injected. This specimen demonstrates an early penetration of the capsular arteries into the cartilaginous head of the femur.

Figure 3 is a specimen taken from a 6 weeks old infant. Injections of the medial circumflex ligamentum teres and nutrient vessels were made. Although none of the injections were entirely satisfactory the opaque material in small amounts reached the capsular arteries and they are clearly demonstrated to be entering the substance of the head of the femur. In fact, one branch penetrates nearly to the nuclear area of the head.

Figure 4 is a femur taken from an infant 14 months of age. In this case the medial circumflex artery was first injected. The inferior capsular arteries can be seen to penetrate into the osseous center and the developing head of the femur.

Figure 4a is a lateral view of Figure 4 and demonstrates the extent to which the capsular arteries supply the growing center of the femoral head at 14 months of age. The nutrient artery was later injected in this same specimen. The injected material filled innumerable end arteries proximal to the epiphyseal line.

Figure 5 shows the femur of a boy 2 years old. In this case the nutrient artery of shaft only was injected. The anastomosis between the nutrient artery of the shaft and capsular arteries of femoral neck is shown. In this instance the capsular arteries of the neck were not injected directly.

Figure 6 is a specimen from an infant 16 months of age. The capsular arteries were first directly injected at a point where they branch from the medial circumflex artery. In this injected specimen is demonstrated very clearly and positively the patterns of distribution of the arteries which contribute blood to the nuclear ossifying center of the head and neck of the femur as early as the age of 6 months. It is apparent that the very small arteries which travel the length of the ligamentum teres supply nourishment to the fovea and a shallow adjacent area of the head of the femur. It is also evident from this specimen that no end branches of the nutrient arteries penetrate the epiphyseal plate area at 6 months of age.

In Figure 7 is presented the specimen from the femur of a boy 7 years of age. In this case the injections were made successively in the nutrient

artery of the shaft, both the superior and inferior capsular arteries and the ligamentum teres arteries. This injected specimen shows that a very extensive blood supply has already been established throughout the head and neck of the femur. Also the capsular arteries are demonstrated to be the most direct and important source of nourishment to the ossifying center in the head of the femur. Fine end arteries or terminal branches of these arteries can be seen to penetrate to the very periphery of the expanding ossifying portion of the femoral head. Some of these minute vessels have given way under the pressure exerted on the opaque fluid, during injection, as can be seen by the collection of lakes of the material in the subcondylar area about the periphery of the head of the femur. In this lateral view, one also notices a few end artery branches of the injected nutrient artery passing through thinned out portions of the dome of the epiphyseal plate. Apparently, then a few of these arteries pierce the substance of the plate as it thins out and play a minor rôle in nourishing the head, later forming an anastomosis with the capsular arteries in this area. Attention is particularly called to the apparent contact between the ligamentum teres vessels and those of the capsular arteries in the ossifying head. (See lateral view of same specimen Figure 7a.)

Figure 7a is a lateral view of the same specimen as in Figure 7. Here again is shown the tremendous fine network of arteries distributed to all portions of the femoral head as the ossifying center expands. However, the significant fact to be noted is that in this view contact has not been made between the capsular arteries and those of the ligamentum teres.

This contact or anastomosis will, undoubtedly, take place as soon as the ossification in the head has extended or expanded to the subfoveal area through the base of which fine terminal branches of the ligamentum teres penetrate for a very short distance during infancy and childhood.

Figure 8 is a specimen from a 10 year old girl. In this case the ligamentum teres and nutrient arteries were injected. Branches from nutrient vessels seem to penetrate the epiphyseal plate and terminate in the ossifying nucleus. The material which was injected by way of the ligamentum teres vessels has failed to enter the head.

Figure 9 is a specimen from a 15 year old boy. The only vessels injected in this instance were the capsular arteries at the base of the femoral neck. During the injection, the opaque material could be seen to drop out through the ligamentum teres vessels, a fact demonstrating the completion of the

anastomosis between the ligamentum teres, the capsular and nutrient vessels.

In this specimen it is also seen that all portions of the shaft, neck and head of the femur are seen to be well supplied with blood vessels. It is apparent that a considerable time before the age of 15 there had been contact established between the blood vessels of the ligamentum teres and the capsular arteries. Also fine branches of these arteries communicate with those of the nutrient artery of the shaft, for although the only injection made was into the capsular arteries as they left the medial circumflex vessel at the base of the neck of the femur, the opaque material penetrated through those vessels and into their anastomosis with those of the nutrient artery in the shaft of the femur.

This specimen likewise disproves the existence of a so called "silent area of nourishment" in the head or neck of the femur.

It is suggested that the use of a large sized reading glass will help materially in the interpretation of the roentgenograms presented.

#### COMMENTS

As a result of our experience it seems reasonable to conclude that the injection method is a practical way of studying the vascular pattern in the head and neck of the femur at different age levels. By this method we have been able to visualize the development of the blood supply which nourishes the ossifying center in the head of the femur during the entire growth period. It also has been possible by this method of study to become informed of the location of the course of the vessels within the femoral neck and head which nourish the growth area from the beginning through to its completion. Obviously such knowledge should prove to be both helpful and satisfying in any approach to a better understanding and treatment of certain hip conditions often met in children. We have in mind especially Legg-Perthes' disease and the so called slipped epiphysis.

#### CONCLUSIONS

- 1 The ossifying center in the developing head of the femur in infants and children receives its blood supply from the visceral capsule vessels which arise from the median circumflex artery.

- 2 The ligamentum teres vessels do not enter the head of the femur in children, nor do they contribute to the nourishment of the growing femoral head, except for very small vessels which accompany the fibrous tissue at the implantation of the ligamentum teres into the fovea area.

3. The anastomosis between the ligamentum teres vessels, the capsular arteries and the nutrient artery of the shaft does not take place until the ossification of the head of the femur is practically if not entirely complete, at which time the vessels of the three systems unite by penetrating the thinned out cartilage area at the forer thus establishing the anastomosis.

4. The ligamentum teres circulation is a closed circulation in so far as the femoral head is concerned until such an anastomosis takes place.

## REFERENCES

- ANASTOMOSIS. Deut med Wochr 925, 5 473
- BERGMANN. Deut Zchr Chir 927 106
3. BOYCE T. Acad. M. Ireland, 555.
4. CELLA. Chir org noviss, 934, 9 807
5. CHASELIER, A. FRIEDSON. Wiscosal M. J 930 35 609.
6. CHASELIER, SIMON B. West Virginia M. J 937 33 97
7. COOPER. Citato da HALLERMAN.
8. DREYERMAN. Arch. Klin Chir 914, 20 764.
9. ELLIOTT. Citato da LEPROUDIN.
- ELIASON, E. L., and FRIEDSON, L. K. Surg. Gyn. Obst 934 58 85.
- ELIOTT. Acta chir scand 1927 6 454.
2. HARRIS, M. and ZIMMERMAN, R. Surg. G. Obst, 930, 57 45
3. HERR. Arch. Klin Chir 9 5, 54 4
4. HILDEBRAND. Zbl Chir 914, 5 19
5. HYRTIL. Zchr der K. K. Gesellschaft der Aerzte, Wien, 846, 53.
6. ISLICH. Cor. Bl. Schweiz. Aerzte, 9 3, 30
7. KOLBOW. J. Bone Surg, 925, 7 573
8. LAUBER. Stuber Akad. Wiss. Mathematur Cl., Wien, 876, 30
19. LIEBER. Pathologische Vorlesung aus Knochenysteme. Berlin. Hirschwald, 904.
20. LOOSEMORE. Chir org noviss. 924, 9 205
- LEUCHE. Das Anatomie des Menschen. Vol. 1, sect. 314. Taubigen H. Lupp, 1865.
2. MARGARELLA. Oref. Policlinico, 937, 44, 104.
3. MOHR. Schratte Morphologische Arbeiten, 1893 50.
24. NEUBAUER. Beitr. Klin. Chir 924 30 493
5. Ibid 926, 37 332
26. PALLISTER. Merckel Arch 4.
27. SUPPE. Trattato di Anatomia descrittiva, Napoli, 873, vol. I, page 669
28. SCHMOLL. Münch med. Wochr 924, 7 51
29. STEWART W. J. J. Bone Surg 925, 51 4 3
30. WALKLEY. J. Anat. Physiol 915, 49 134
3. ZIMMERMAN and LIEBER. W. Surg. Gyn. Obst 1929 48 46

# CHEMICAL CONSIDERATIONS GOVERNING THE LOCAL CHEMOTHERAPY OF WOUND INFECTIONS

FRANZ C. SCHMELLES, Ph. D., Belleville, New Jersey

**A**LTHOUGH it is well recognized that the concentration of hydrogen ions fundamentally influences most physiological processes, its effect upon the healing of wounds and epithelization has not been investigated extensively. While the hydrogen ion concentration (pH) of different tissues varies considerably, it deviates only in special instances from that of the circulating blood. The importance of maintaining hydrogen ion concentration in tissue repair is suggested by the fact that tissue growth in culture media proceeds at an optimum rate at hydrogen ion concentration 7.5.

Most pathogenic bacteria on the other hand produce acid from their metabolites, particularly from carbohydrates, although there are several exceptions, especially among those with predominantly proteolytic activities. Although few data are in the literature on the hydrogen ion concentration of infected wounds, there is general agreement that infection produces acidity. In a recent study<sup>1</sup> the hydrogen ion concentration of grossly infected wounds is found to be below pH 6 and in some instances approached pH 5. As the infection clears up the hydrogen-ion concentration of the wound secretions decreases while in a clean healing wound it is usually about pH 7.5.

From Menkin's data<sup>2</sup> it appears that inhibition of wound repair in infected wounds may be due at least in part to the low hydrogen ion concentration of pus. An interesting example of this effect occurs in the treatment of burns with tannic acid solution (pH of 3.5 to 4). The purpose of using tannic acid is to produce a clogging effect by precipitating protein on the burned surface, a process

frequently considered similar to the tanning of hides although different in many respects. The precipitation of proteins by tannic acid is incomplete or even absent at neutral or slightly alkaline reaction and its optimum is at about pH 4. Eschar formation at alkaline reaction may therefore be delayed considerably. Moreover the alkaline tannates are highly susceptible to oxidation which is further favored by the fine state of subdivision brought about by spraying in air. The use of tannic acid at pH 7 is therefore impractical. It is now gradually becoming recognized that the treatment of burns with tannic acid solutions of low hydrogen ion concentration is to some extent a compromise, and in borderline cases tissue destruction by tannic acid may convert a second degree burn into a third degree burn.

In this connection it is of interest to note that some of the established agents used in wound and burn therapy are buffered to slightly above neutrality. This seems to be more than mere coincidence. The hydrogen ion concentration of Dilme's solution is pH 8.5, of the peroxide suspension pH 7.8, of a chloranil solution, pH 7.4, of Picrol's solution pH 6.6.

The influence of hydrogen ion concentration on the effect of various antibacterial agents has been extensively investigated. It has been found that most agents possess a more or less wide hydrogen ion concentration range of optimum activity and that the activity of antibacterial chemicals usually decreases at high acidity and alkalinity (4, 5). It is also known that the effectiveness of agents of a basic nature, such as quaternary ammonium derivatives, acridine dyes, and similar agents, increases with a rise of hydrogen ion concentration, whereas that of acid agents, as the halogens, phenols, and the like, decreases with increasing hydrogen ion concentration.

*Effect of hydrogen ion concentration on the action of sulfonamides.* Recently our laboratory and others drew attention to the importance of the ampholytic character of the sulfonamides (3, 10). Ampholytes are compounds which can react as acids or bases, depending on the hydrogen ion concentration of the medium. The effect of hydrogen ion concentration on sulfonamide ac-

Because of his outstanding contributions in the field of chemotherapy, the late Dr. Schmelles was invited by the Agents of the American College of Surgeons to participate in the 1917 Clinical Congress of the College, which had to be cancelled because of the war emergency. It is fortunate for all of us that Dr. Schmelles' paper was completed shortly before the untimely death of this brilliant scientist. The members of the Department of Surgery of the Johns Hopkins Medical School consider themselves fortunate in having been in close association with Dr. Schmelles, and his co-operation and advice have been very helpful to all of us. I take personal pride in having rejected the preparation of this his last paper — *MYRON DIAMOND*.

From the Research Department Wallace & Tiernan Froduct, Inc.

<sup>1</sup>Dr. James A. Dingvall, Department of Surgery, Cornell University Medical School, personal communication.

TABLE I.—EFFECTIVENESS OF VARIOUS SULFONAMIDES IN OVERCOMING THE ACTION OF *p*-AMINOBENZOIC ACID AS MEASURED AGAINST *ESCHERICHIA COLI* IN A SYNTHETIC MEDIUM

PH	SA (K PERMUT)	SP (K EXTRA)	ST (K-4 PERMUT)
	0.00000	0.0000	0.000
5.5	0.00030	0.0000	0.000
6	0.00060	0.000	0.00
6.5	0.0012	0.000	0.00
7	0.002	0.000	0.00
7	0.004	0.00	0.00
8	0.008	0.00	0.00

tion  $\alpha$  was thoroughly investigated, and it was found that sulfonamides behave as though their effectiveness were proportional to their acid strength. Results of experiments given in Table I show that the antibacterial effectiveness of various sulfonamides increases with increasing hydrogen-ion concentration throughout a relatively wide hydrogen-ion concentration range.

These observations may have some bearing on the accepted theory which explains the action of sulfonamides on the basis of competition with *p*-aminobenzoic acid which is a stronger acid than any of the commonly used sulfonamides. The competitive antagonism between *p*-aminobenzoic acid and sulfonamides is usually explained on the basis of their close structural similarity which enables the sulfonamides to block that part of an essential enzyme (that is usually occupied by *p*-aminobenzoic acid (3, 12). Since it has been found that the anionic form of the sulfonamides competes with *p*-aminobenzoic acid on much more favorable terms than the molecular form, at least at or below pH 7 a rise in the hydrogen-ion concentration of the surrounding medium causes increased dissociation of the sulfonamide molecules into anions and greatly increases their antibacterial effectiveness.

TABLE III.—EFFECT OF HYDROGEN ION CONCENTRATION ON GROWTH INHIBITION OF *STREPTOCOCCUS FECALIS*\* BY SULFONAMIDES

Compound	mgm <sup>a</sup> required to reduce growth to 1/2 maximum rate at	
	pH	pH
Sulfanilamide	50	0.5
Sulfapyridine	30	0.009
Sulfathiazole	0.5	0.006

\*This compound grows readily in synthetic media at pH

TABLE II.—ION ACTIVITY OF SULFOXAMIDES<sup>a</sup>

pH	(S-1)/(P-1)	(S-2)/(P-2)	(S-3)/(P-3)	(S-4)/(P-4)
		34	90	100
6	3	37	96	100
6.5	38	94		96
	36			172
	6			

\*The values given are arrived at by determining the concentrations of monomeric acid and sulfonamide at which the growth rate of a set of organisms is reduced to one-half maximum. The same values are then calculated from the dimers, oxalate and the higher ion concentrations. The values of the fraction sulfonamide bound to monomeric acid (shown in parentheses) are given in the table.

[Extrapolated from determinations carried out at slightly different polymer ion concentrations.]

A careful quantitative investigation has shown that regardless of the hydrogen-ion concentration, the competitive ratio of the anions of the sulfonamides to the  $\beta$ -aminobenzoate ion ( $SA/PAB$ ) at equal growth inhibition is a characteristic of each compound.

A comparison of various sulfonamides showed that each of them possesses a specific anionic activity and that sulfanilamide leads the list. While each sulfanilamide anion can overcome from 1:5 to 1:3 *p*-aminobenzoate ions, 3 to 6 sulfathiazole ions and 200 sulfacetamide ions are required to suppress the action of one *p*-aminobenzoate ion. This high activity of the sulfanilamide anions would not be confused with the fact that sulfanilamide is the least effective of the commonly used sulfonamides when they are compared on a weight basis at pH 7. As the hydrogen-ion concentration is raised, increasing larger fractions of the total sulfanilamide dissociate into the much more powerful anionic form with simultaneous increase of the antibacterial effect. Table II shows that at pH 9 the activity of sulfanilamide is about equal to that of sulfathiazole and sulfapyridine. Since sulfanilamide is very much more soluble than sulfathiazole and sulfapyridine, a nearly saturated sulfanilamide solution at pH 9 would be more effective than that of any other sulfonamide.

Since the systemic hydrogen-ion concentration cannot be influenced by medication, these considerations are not applicable except in local chemotherapy where buffered materials can be used to maintain the hydrogen-ion concentration at a level favorable to sulfanilamide action.

These findings provide an explanation for many contradictions in the literature and point to the readiness of carrying out all comparative studies sulfonamide action upon bacteria in heavily

buffered media in order to exclude variations in hydrogen ion concentration level due to the metabolic activities of the bacteria under investigation. Furthermore, these observations suggest that in local sulfonamide therapy the hydrogen ion concentration level be raised to a point as high as is compatible with physiological processes. Finally, it appears to be advisable to apply instead of the more complex relatively insoluble sulfonamides, the more freely soluble sulfonamide which is not only equally effective on a weight basis but in addition is present in a higher local concentration.

Recently Roblin and Bell presented in their own hypothesis correlating chemical structure with the activity of various sulfonamide derivatives. They suggest that the sulfonamide group is one of the sulfonamides determines the state of polarization of the sulfone group which in turn is responsible for the sulfonamide activity. Some of our experimental findings agree with this hypothesis.

*Effect of certain polar compounds upon sulfonamide action.* In addition to the polar groups in the sulfonamide molecule which have been shown to be factors of paramount importance it is not at all impossible that the hydroxyl ions of the surrounding medium which increase in concentration as the hydrogen ion concentration level is raised may have an effect of their own upon sulfonamide action.<sup>1</sup> With other polar compounds such effects have been demonstrated. Urea (6-15%) and asparagin exert in some manner so far not understood, a "medium effect" upon either the sulfonamide or the bacteria. Asparagin is actually a growth stimulant in the presence of which bacteria proliferate more rapidly. To our knowledge it is the only compound known to stimulate bacterial growth and to enhance sulfonamide activity at the same time.

*Inactivation of sulfonamide inhibitors.* In addition to the enhancement of sulfonamide action by adjustment of the hydrogen ion concentration to the optimum value compatible with physiological conditions by use of the "medium effect" of one or the other polar substance, sulfonamide action may also be greatly enhanced by direct inactivation of the specific sulfonamide inhibitors which are always present in pus, necrotic tissue, etc. Recent evidence points to the possibility that this may be effectively and almost selectively accomplished by the action of mild

TABLE IV—EFFECT OF UREA AND ASPARAGIN UPON THE INHIBITION OF *ESCHERICHIA COLI* BY SULFANILAMIDE

Conc. of sulfanilamide	Conc. of urea or asparagin			
	0	0.01	0.05	0.1
0	0	0	0	0
0.01	0	0	0	0
0.05	0	0	0	0
0.1	0	0	0	0
0.5	0	0	0	0
1.0	0	0	0	0
2.0	0	0	0	0
5.0	0	0	0	0
10.0	0	0	0	0
20.0	0	0	0	0
50.0	0	0	0	0
100.0	0	0	0	0

oxidizing agents, particularly by one of the chlorine compounds (6, 11, 15, 17, 20). As all organic matter including the sulfonamides reacts with oxidizing agents the use of a highly selective chlorination compound is indicated and has actually been found to give the best results. If the inhibitor in pus is identical with *p*-aminobenzoic acid it is noteworthy that a trace of azochloramid, less than the concentration required to show a marked effect upon the bacteria present is able to inactivate an amount of *p*-aminobenzoic acid present in the pus of infected wounds.

Another interesting phenomenon is the marked effect azochloramid has upon strains which have become resistant to the action of sulfonamides.

At the present time the effect has been demonstrated only with oxidizing agents such as azochloramid (Table V).

TABLE V—EFFECT OF AZOCHLORAMID AND *p*-AMINOBENZOIC ACID ON THE INHIBITION OF *ESCHERICHIA COLI* BY SULFANILAMIDE

Conc. of sulfanilamide	Conc. of azochloramid		Turbidity (0.5 hr.)
	<i>p</i> -Aminobenzoic acid	Azochloramid	
0	0	0	34.0
0.01	0	0.1	31.0
0.05	0	0	28.0
0.1	0.1	0	21.5
0.5	0.05	0	26.0
1.0	0.01	0	0
5.0	0.1	0.1	1.5

<sup>1</sup>Some of our unpublished data indicate that the hydrogen ion concentration level also influences the effectiveness of the sulfonamide in the sulfonamide benzoic acid reaction into anions. These new findings present new interest in their effect on the

<sup>2</sup>Unpublished data of Dr. Orville Wyss.



TABLE VI.—EFFECT OF APOCHLORAMID AND SULFANILAMIDE UPON SULFANILAMIDE FAST ESCHERICHIA COLI

Inoculum: 1,000,000 <i>Escherichia coli</i> per milliliter		
Sulfanilamide mgm. %	Apochloramid mgm. %	Turbidity 5 hrs.
		46.0
100		4.5
1		47.5
	64	44
1	64	5

TABLE VII.—THE VALUE OF BUFFERED SULFANILAMIDE IN PROPHYLAXIS

No. of Cases	Drug employed: 7-8 gm.	Primary healing: Cases %	Infected wound: Cases %	Average no. of days in hospital after surgery
32	Polychloramide	69	30 31	37
	Iskitchloramide	100	None	30.4
29	Xero	31 3	8 27	42.1
16	Buffered sulfanilamide	57 36	6	33.6

*Application of these findings in the local therapy of wounds and burns:* As has been shown, infected wounds are acid. Sulfonamides in general are much less active under acidic conditions and between pH 5 and 6 even the more active compounds, sulfathiazole and sulfadiazine, exhibit only a fraction of their maximum activity. The activity of sulfonamides can be increased by raising the hydrogen-ion concentration, which increases their dissociation and apparently also increases the effectiveness of the molecular form. While the more active compounds, sulfathiazole and sulfadiazine, are largely dissociated at pH 7 the activity of sulfanilamide can be raised to that of sulfathiazole and sulfadiazine by raising the hydrogen-ion concentration from slightly above the neutral point up to pH 9. Due to the much greater solubility of sulfanilamide, a local chemotherapeutic effect might be had at pH 9 that would exceed that of sulfathiazole and sulfadiazine.

A dusting powder was therefore prepared which consisted of sulfanilamide buffered with calcium carbonate to approximately pH 8.8. Calcium carbonate was selected because it acts not only as a buffer but also as a reservoir of buffer. Calcium carbonate is insoluble and becomes soluble only to the extent that acid is produced in the wound and that its buffering ability is called into play. Thus it is possible to insure the presence of adequate amounts of buffer for about as long period as sulfanilamide is present in the wound.

Recently the sodium salts of sulfonamides have been proposed for local chemotherapy (2). It should be borne in mind that some of the sodium salts of sulfonamides are too alkaline for use on tissues, while others which yield less alkaline sodium salt solutions, such as sulfathiazole and sulfadiazine, do not increase in activity when the hydrogen-ion concentration level is raised beyond that of the tissues. The use of sparingly soluble buffer is indicated because it maintains the alkaline reaction for a relatively long period of time.

The buffering action of highly soluble sodium sulfonamides is fleeting.

Preliminary clinical investigations with buffered sulfanilamide powder have borne out these theoretical considerations. Captain J. V. Scott at the Station Hospital at Fort Belvoir, Virginia, has treated a series of contaminated wounds resulting from the excision of pilonidal cysts with the results shown in Table VII. These wounds were primarily closed after the chemotherapeutic agents were implanted. Calcium carbonate has additional theoretical advantages inasmuch as it has been shown by Hamburger that calcium ions stimulate phagocytic activity.

Another application of the buffering principle for the treatment of burns. It has been pointed out here that the acidity of tannic acid interferes with full utilization of the antibacterial effects of the sulfonamides. Moreover the acidity of the solution itself may impair the rate of tissue repair. This was kept in mind in preparing the preformed therapeutic membranes which have recently been discussed by Andrus, Nickel and the writer in a preliminary communication. These membranes consist of a transparent hydrophobic plastic, contain 10 to 30 per cent sulfonamide and are buffered with calcium carbonate. They also contain resins which as here mentioned, was found to enhance sulfanilamide action and a small quantity of sodium tetradecyl sulfate which reduces surface tension and provides adherence to the burns. The sterile film is moistened with apochloramid solution and then placed over the cleansed and debrided burned area, covered with a pressure dressing and the lesion immobilized. In the treatment of second degree burns, for which this film has been largely utilized, rapid epithelialization and freedom from infection has been reported. Quite recently Pickrell reported excellent results with a film of somewhat similar composition. The rapidity and simplicity of application does away with time-consuming spraying. During the first

Encountered in immediate results of radical excision of pilonidal cysts with primary wound closure by the use of buffered sulfanilamide powder—(Dr. Scott).

TABLE VIII —STREPTOCOCCAL EMPYEMA

Date	Treatment	Concentrations of sulfanilamide (mgm %) in empyema fluid	Approximate number of streptococci per c.c. of empyema fluid
2-4-42	S	12.65	>1 000 000
2-5-42	S	9.38	5 000 000
2-6-42	S	9.2	5 000 000
2-7-42	S AS		
2-8-42	S		2 400
2-10-42	S	13.2	400
2-11-42	S	12.0	
2-12-42	S	8.52	8
2-14-42	S AS	3.6	1
2-16-42	S	6.0	0

S=Sulfanilamide (per os)

AS=Azochloramid-sulfanilamide solution (intrapleurally)

—No determinations carried out.

48 hours the films are easily removable by simple sponging with a sterile aqueous solution. After the burn is healed the film flakes off spontaneously. From the military viewpoint it is of great importance that this film might be used successfully as an emergency dressing preceded by superficial cleansing only. After an interval of not more than 48 hours, definitive treatment can be instituted if it seems desirable to carry out thorough debridement. The emergency application prevents further damage to the patient at a time when the number of casualties overtaxes the available personnel and facilities. Finally, the compactness of this material makes it easy to ship which, under present conditions, is a desirable feature.

The clinical effect of oxidizing agents when used with sulfonamides has been discussed by Goldberger and by Neter, who have commented upon the rapid cleanup of local infections which were treated with mixtures of sulfonamides and azochloramid. A table taken from Neter's recent paper shows the effect of a few milligrams of azochloramid upon the bacterial count in an empyema fluid which was refractory to sulfonamide therapy alone. Neter has used freshly prepared mixtures of sulfanilamide and azochloramid. This is important because azochloramid slowly reacts with sulfanilamide and thereby loses its effectiveness (Table VIII).<sup>1</sup>

Methods of simultaneous application of azochloramid and sulfonamides were recently de-

scribed by Hanrahan and by Long. They have also discussed indications for using this combination (8, 10).

## SUMMARY

Recent studies of their mode of action have shown that the effectiveness of sulfonamides is greatly influenced by the hydrogen-ion concentration of their environment. This is due to the fact that the sulfonamide anions are much more active than the undissociated molecules. Among the sulfonamide anions, the sulfanilamide anions possess the greatest specific activity. At pH 8.5 to 9 sulfanilamide is not completely dissociated, yet it is as active as sulfathiazole or sulfadiazine. Some polar compounds, such as urea and asparagin, increase sulfonamide activity. Oxidizing agents, particularly azochloramid, also have an enhancing effect on sulfonamide action. This can be attributed to the destruction of sulfonamide inhibitors. The therapeutic applications of these findings is discussed.

## REFERENCES

- ANDRUS, W. DE W., NICKEL, W. F., and SCHMILLAES, F. C. Arch. Surg. In press.
- FOX, C. L., JR. Arch. Surg., 1942, 45, 754.
- FOX, C. L., JR., and ROSE, H. M. Proc. Soc. Exp. Biol., N. Y., 1942, 50, 142.
- GRSHFELD, L., and PERLSTEIN, D. Am. J. Pharmacy, 1941, 113, 89.
- Ibid., 1941, 113, 237.
- GOLDBERGER, H. A. Am. J. Surg., 1942, 56, 353.
- HAMBURGER, H. J. Proc. Konink. Akad. Amsterdam, 1910, page 66.
- HANRAHAN, E. M. Surg. Clin. N. America, 1942, 22, 1275.
- HOLDR, H. G., and MACKAY, E. M. Mil. Surgeon, 1942, 90, 509.
- LONG, P. E. Surg. Clin. N. America, 1942, 22, 1320.
- MENKIN, V. The Dynamics of Inflammation. New York: The Macmillan Co., 1940.
- NETER, E. Proc. Soc. Exp. Biol., N. Y., 1941, 47, 303.
- Idem. J. Pharm. Exp. Ther., 1942, 74, 52.
- Idem. Am. J. Surg., 1942, 58, 69.
- OLSON, M., SLIDER, E., CLARK, W. G., and MACDONALD, R. Proc. Soc. Exp. Biol., N. Y., 1942, 49, 396.
- PICKRELL, K. L. Bull. Johns Hopkins Hosp., 1941, page 304.
- ROBIN, R. O., JR., and BILL, P. H. Presented before the Division of Medicinal Chemistry of the American Chemical Society, Buffalo, New York, September 1942.
- SCHMELKES, F. C., and WYSS, O. Proc. Soc. Exp. Biol., N. Y., 1942, 49, 263.
- SCHMELKES, F. C., WYSS, O., MAPES, H. C., LUDWIG, B. J., and STRANDSKOV, F. B. Proc. Soc. Exp. Biol., N. Y., 1942, 50, 145.
- TSUCHIDA, H. M., TILSTNER, D. J., CLARK, W. G., and STRAKOSCH, F. A. Proc. Soc. Exp. Biol., N. Y., 1942, 50, 76.
- WOODS, D. D. Brit. J. Exp. Path., 1940, 21, 74.
- WYSS, O. Proc. Soc. Exp. Biol., N. Y., 1941, 47, 111.

<sup>1</sup> After extensive research it has been possible to produce a stable mixture of azochloramid and sulfanilamide which, in the form of a sterile, airtight, time powder, has been used successfully in the treatment of wound infections.

# THE MAXIMAL VOLUME OF THE HUMAN SPLEEN

PATRICK P T WU M.D., M.S. (Exper Surg.) Ph.D. (Exper Surg.) F.A.C.S., Rochester Minnesota

ONE of the romantic episodes in medicine is the accidental way in which the function of the spleen as a blood reservoir was discovered. In 1921 Barcroft and his party were on a voyage to the Peruvian Andes to study mountain sickness. On reaching tropical waters, members of the party discovered that the blood volume and the concentration of hemoglobin had increased whereas, after they crossed the equator and reached colder regions, these values declined again. It appeared that the extra amount of blood had been first released from and subsequently returned to a considerable but then hidden storehouse. The spleen was suspected of being such a reservoir. Experiments on animals in the laboratories in the course of time proved this to be true.

The weight of a normal spleen from an adult man is notoriously susceptible to great variations. In one standard textbook of human anatomy the range was set between 100 and 250 grams, whereas in another it was put at 80 to 300 grams. In a statistical study of the weights of 4,000 normal spleens, Krumpholtz and Lippincott found the average weight of the spleen to be 70 grams when a person is from 16 to 30 years of age, 155 to 160 grams when the person is between 36 and 65 years old and progressively less after the age of 65 years has been attained. Kasemann believed that spleens weighing more than 30 grams probably are not normal, whereas Bell considered any spleen weighing more than 300 grams as nearly always abnormal in some respect.

Ahrenheim has demonstrated by experiments with modeling clay that one cannot compute without gross error the volume of the spleen on the basis of measurements of the length, width and thickness of the organ. The author cannot agree with him, however, that weight appears to be the most nearly accurate way of expressing the size of an organ.

The efficiency of the spleen as a blood reservoir would be limited, indeed, if its capacity were judged on the basis of weight as determined at postmortem examination. Hunting has pointed out that the difference between the weight of a normal human spleen and that of another washed

free of blood is only 40 to 50 grams. It would seem, however, that the crux of the matter lies rather in the magnitude of the difference between the volume of the spleen during life and the volume of the same spleen after death. Barcroft and his colleagues demonstrated in the cat the striking phenomenon that the spleen during life might be two to four times greater than it is after death from hemorrhage or drowning has occurred. Does this apply to the spleen in man? The answer is hard to obtain, because in the medical literature there is a dearth of information on the maximal volume of the human spleen.

## NATURE OF THE STUDY

The purpose of this study was to inquire into the maximal volume of the normal spleen in man with particular reference to its provision of a potential space for the storage of blood. Since the medical profession is now keenly interested in the question of blood banks, this seems to be an opportune time at which to assay the capital that may exist in reserve in this vicarious bank in the human body.

## MATERIAL AND METHOD

The material used in this study consisted of spleens which were obtained from a series of 30 unembalmed bodies at postmortem examination at the Mayo Clinic. Fourteen spleens were obtained within 4 hours after death of the patients and 5 others in less than 9 hours after death of the patients. One spleen was taken from a patient who had died 3 days previously at another hospital.

Spleens were secured from 15 males and 5 females, whose ages had ranged from 6 to 89 years. There was 1 patient each in the second and fourth decades, 2 patients each in the third and fifth decades, 4 each in the sixth and seventh decades, and 3 each in the eighth and ninth decades. The height of the males varied from 158 to 87 centimeters, and that of the females varied from 155 to 77 centimeters. The weight of the males ranged from 90 to 201 pounds (41 to 91 kgm.) and that of the females from 100 to 150 pounds (45 to 68 kgm.) The surface area was computed according to the formula of Dubois, with the aid of the nomogram devised by Boothby and Sandiford.

The work was done under the direction of Dr. H. E. Robertson, Section on Pathologic Anatomy, Mayo Clinic. Dr. W. Johnson, Mayo Foundation.

TABLE I—MEASUREMENTS OF TWENTY SPLFENS OBTAINED AT NECROPSY AND CERTAIN DATA CONCERNING PATIENTS FROM WHOM SPLEENS WERE OBTAINED

Case No	Patient					Spleen				Body	
	Sex	Age	Height cm	Weight lb	Surface area sq meter	Weight gm	Initial volume c.c	Maximal volume c.c	Difference in volume, c.c	Computed blood volume c.c.	Spleen body blood volume ratio per cent*
507	M	16	184	15	1.75	145	140	225	85	5775	1.5
561	M	24	178	126	1.7	255	235	440	205	5676	3.6
547	M	25	187	140	1.86	355	320	650	330	6138	5.4
582	F	18	161	100	1.44	105	105	310	205	4752	4.3
118A	M	46	186	145	1.88	265	230	365	135	6204	2.2
526	M	48	183	170	1.99	270	250	650	400	6567	6.1
132A	M	51	177	165	1.92	200	200	480	280	6336	4.4
142A	M	55	172	125	1.67	200	180	375	195	5511	3.5
589	M	55	176	200	2.08	300	300	450	150	6864	2.2
600	M	57	177	135	1.76	140	150	425	275	5808	4.7
515	F	64	156	145	1.66	110	100	200	100	5478	1.8
539	M	65	168	127	1.65	150	140	250	110	5445	2.0
559	M	66	180	201	2.12	360	350	500	150	6996	2.1
120A	F	67	155	102	1.42	135	125	285	160	4686	3.4
522	F	70	172	150	1.80	185	175	315	140	5940	2.4
131A	M	72	171	140	1.74	235	225	500	275	5742	4.8
628	F	76	162	110	1.52	130	137	300	163	5016	3.2
122A	M	80	160	115	1.53	115	125	200	75	5049	1.4
126A	M	82	165	90	1.41	60	60	120	60	4653	1.3
585	M	89	164	115	1.56	105	140	355	215	5148	4.2

\*Computed thus: in case 526 the computed blood volume of the body was 6567 c.c. The spleen in the same case had a potential capacity to store 400 c.c. of blood which is 6.1 per cent of the total blood volume of the body (6567 c.c.)

Only those spleens which were normal on inspection and palpation were used in this study. Twenty such spleens were secured. First, they were weighed. The volume of the spleen was determined by noting the amount of water displaced when the spleen was submerged in that medium. Henceforth in this study this particular volume will be called the "initial volume" of the spleen.

Next, a glass cannula was inserted into the splenic artery and tied in place. A piece of rubber tubing was used to connect the cannula with a water faucet. The spleen was immersed in water, and air was removed from the perfusion system. The tap water was turned on gradually, until the spleen became distended and blood began to issue freely from the splenic vein. Perfusion was continued for from 15 minutes to half an hour, until the maximal amount of distention, short of that which would produce rupture of the splenic capsule, was obtained. Then the volume of the spleen was determined again by the method of displacement of water. The volume thus obtained will be

called the "maximal volume" of the spleen. The difference between the maximal and the initial volumes of the spleen is taken as the potential capacity of the organ as a blood reservoir (tenth column in Table I).

#### RESULTS

Pertinent data and results of this study are given in Table I. The volumetric determinations are graphically represented in Figure 1. A number of points seem to be interesting enough to need elaboration.

The weights of the spleens in this series varied from 60 to 360 grams. Sixteen of the 20 spleens weighed between 105 and 270 grams.

The initial volumes of the spleens varied from 60 to 350 cubic centimeters. Both of the patients concerned were males, 82 and 66 years old, respectively. The range of variation in initial volume among the females was between 100 and 175 cubic centimeters. Twelve of the 20 spleens had initial volume between 100 and 200 cubic centimeters, inclusive.

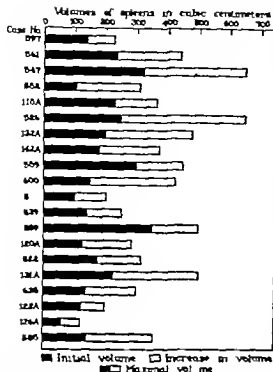


Fig. 1. The initial volume of the spleen is represented by the solid black area. The difference between the maximal and the initial volumes of the spleen is represented by the hatched area. The solid black and the hatched areas together represent the maximal volume of the spleen. Note particularly cases numbered 545, 547, 525, 600 and 8.

The maximal volumes of the spleens varied from 120 to 650 cubic centimeters; these values apply to the 15 males as well as to the whole series (Table I). The spleens from the 5 females had maximal volumes of 200, 350, 350 and 315 cubic centimeters. It is noteworthy that only 4 spleens in the series of males had volumes less than 350 cubic centimeters (120, 200, 225 and 250 c.c., respectively) and that the remaining 11 spleens had volumes in excess of that figure.

The ratios between the maximal and the initial volumes of the spleens are summarized in Table II. The maximal volumes of 8 spleens were one and a half times to twice the corresponding initial volumes. In the case of 8 other spleens, the maximal volumes were two, to two and a half, times the initial volumes. It is particularly noteworthy that the remaining 4 spleens possessed maximal volumes which were two and a half to three times the initial volumes. In other words, the volume of the spleen during the life of the patient could be two to three times that after death in 3 out of every 5 cases in this study (Table II).

TABLE II.—MAXIMAL VOLUMES OF SPLEENS

Ratio to initial volume*	Spleens, no.
1 to 2.0 times	8
2.0 to 2.5 times	1
2.5 to 3 times	4

\*Initial volume\* taken as in this table.

The difference between the maximal volume and the initial volume of the spleen gives the most instructive figure in this study (Table I). As pointed out previously herein, it represents the potential capacity of the spleen as a blood reservoir. It should be said at this time that much blood was washed out during perfusion in all the specimens, without exception. The actual potential space in the spleens must therefore be appreciably greater than the figures here given would indicate.

The potential capacities of the spleens which were measured in this study varied from 60 to 400 cubic centimeters. This range applied to the spleens from the males as well as to those in the whole series. In the case of the females, the range of variation was between 100 and 205 cubic centimeters (Table I). Measurement of 5 spleens in respect to potential capacity produced these significant figures: 275, 275, 80, 350 and 400 cubic centimeters.

#### OBSERVATIONS

Most of the material used in this study was obtained from elderly persons, as is apparent in Table I. Only 4 patients had been younger than 45 years of age, whereas exactly half of the total number were more than 60 years old. Because the spleen serves much like a mechanical, chemical, and biological filter in the economy of the body, it is difficult to conceive of any systemic disease which would not leave, in its wake, certain alterations in the capsule and the connective tissue framework of the spleen. This may be added that as yet ill-understood structural expression of senescence itself. The consequence is that the extensibility and contractibility of the organ must necessarily, albeit varying in degree, diminish during the span of life of any person. In other words, the capacity of a perfectly "normal" spleen to serve as blood reservoir should be even greater than the results of this investigation would indicate, since most of the spleens in this study were obtained from persons already "senescent" at the time of death. In fact, the situation of the spleen in the portal circulatory system would lead one to suspect that the peak of its efficiency in this important rôle might be reached during the fetal life of the person.

The initial volume of the spleen is measured in this study merely provides a sort of base line for each individual case. It possesses no value whatsoever for comparison among cases. The reason is that the initial volume is dependent on the degree of distention or collapse of the organ. A multitude and diversity of factors may play varying roles during the terminal period of life. As examples may be mentioned hemorrhage shock, collapse, asphyxia, and physical exertion, all of which cause contraction of the spleen. The administration of epinephrine, pituitrin and other sympathicomimetic drugs is known to exert the same effect. The effects of the transfusion of blood and of vasoconstrictors of various solutions may be reflected in an opposite direction. Finally such conditions as congestive heart failure, cirrhosis of the liver with portal hypertension, and mechanical obstruction in the portal venous system tend to impede the emptying of the spleen. It is thus easy to comprehend why the initial volumes varied so much, is from 60 to 350 cubic centimeters. The wonder is that the discrepancy was not greater.

On the other hand, the maximal volume of the spleen is free from the influence of such variable factors. It is obtained under a constant set of experimental conditions. Theoretically the capacity of the spleen for the storage of blood should vary directly in proportion to its maximal volume. But this relationship is nullified by the great variation in the initial volume of the spleen, as noted previously herein. Take, for example, the 10 spleens which had a maximal capacity of 500 cubic centimeters each (Table I). The capacity for blood storage is estimated by the method of measurement employed in this study would be 275 cubic centimeters for one as against 150 cubic centimeters for the other. The difference between them is the difference between the initial volumes of 225 and 350 cubic centimeters, respectively. When the maximal volume of the spleen is plotted against the surface area of the person from whom the spleen was taken, a positive linear relationship between the variables is seen (Fig. 2). The line in the figure was calculated according to the method of least squares. Four of the five females had surface areas of less than 1.70 square meters, whereas 10 of the 15 males had surface areas greater than that figure. Interestingly enough, the maximal volumes of the spleens in the males and the females tended to group themselves above and below 325 cubic centimeters, respectively. It may be stated that the maximal volume of the spleen seems to vary directly in proportion to the surface area.

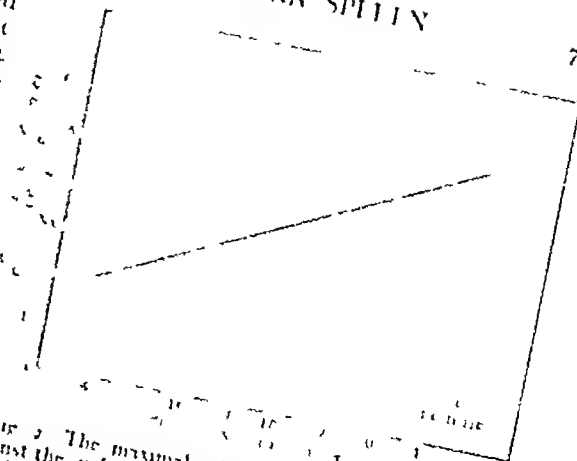


Fig. 2. The maximal volume of the spleen is plotted against the surface area of the person concerned. The line is calculated according to the method of least squares. Note the positive linear relationship between the variables.

The difference between the maximal and the initial volumes of the spleen as reported in this study represents only the lower limit of the potential capacity of the organ is a blood reservoir. The evidence thereof lies in the fact that it required from 30 minutes to 2 hours of continuous perfusion to rid the spleen of its residual content of blood. In other words, the actual storage capacity of the spleen must be appreciably greater than the figures obtained in this study would indicate. In view of this fact particularly significant are these figures 400, 330, 280, 275 and 275 cubic centimeters, seen in the tenth column of Table I. In terms of percentage of the total blood volume calculated on the basis of the 6.1, 5.4, 4.4, 4.7 and 4.8 per cent, respectively seen in the first column of Table I. These spleens should be able to carry out autotransfusion of a considerable amount of blood when the demand for it arises. Provisions such as this testify to what Cannon called "the wisdom of the body."

The weights of the spleens in this series varied from 60 grams in 1 case to 366 grams in another. If the specific gravity of the blood is taken to be 1.055, the 60 gram spleen when distended with blood would weigh 123 grams and the 366 gram spleen when distended with blood would weigh 518 grams. An extreme instance was found in the case of the spleen which weighed 270 grams when it was distended with blood, that spleen would weigh 692 grams, which is two and a half times the actual weight. The anatomists and the

\*The author is indebted to Mr. Robert P. Clegg of the Division of Biometry and Medical Statistics of the Mayo Clinic for his assistance in the statistical analysis.

pathologists therefore should correlate the weight of the spleen with its degree of distention or collapse. One begins to wonder when one should use the erudite polysyllabic term 'splenomegaly' which, to begin with, has no more meaning than that expressed by an increase in size and weight of the spleen. Certainly the clinician who has been able to palpate a spleen during the life of a patient would have to subdue his feeling of pride in the feat when he sees the same but more or less contracted spleen at postmortem examination.

#### SUMMARY AND CONCLUSIONS

The volumes of 20 spleens obtained from unembalmed bodies at postmortem examination were measured by means of the amount of water they displaced. Then the spleens were distended by perfusion with water to produce maximal volumes.

The initial volumes of the spleens varied from 60 to 350 cubic centimeters. The factors which could be responsible for such variation have been pointed out. It is suggested that the weight of the spleen should be correlated with its degree of collapse or distention with blood.

The maximal volumes of the spleens seemed to vary in direct proportion to the surface areas of the patients. The values for maximal volume ranged between 120 and 650 cubic centimeters. They represented one and a half to two times the initial volumes in the case of 8 spleens, two to two and a half times in 8 other spleens, and two

and a half to three times in the remaining 4 spleens.

The difference between the maximal and the initial volumes of each spleen represented in large measure the potential space available for storage of blood. This varied from 60 to 400 cubic centimeters. Great significance was attached to 5 spleens which possessed the capacity to accommodate 275, 275, 280, 330 and 400 cubic centimeters of blood representing 4.8, 4.7, 4.4, 5.4 and 6.1 per cent respectively of the total blood volumes of the patients concerned.

#### REFERENCES

1. ARROSTHERS, J. H. Arch. Path. Clin. 9: 535-51.
2. BARNETT, JOSEPH. Lancet, Lond. 915, 319-321.
3. BALL, E. T. A Text-book of Pathology 4th ed. Philadelphia Lea & Febiger 93.
4. BENTON, C. H. Diseases of the spleen. In Tice, Frederick. Practice of Medicine Vol. 2, pp. 513-517. Hagerstown, Maryland W. F. Prior Company Inc. 93.
5. CANNON, W. B. The Wonders of the Body New York W. W. Norton & Co. Inc. 932.
6. GRAY, HENRY. Anatomy of the Human Body Philadelphia Lea & Febiger 94.
7. K. CUNNINGHAM, E. Pathology for Students and Practitioners. (Translated by Robinson, S. P.) Vol. 2, 2d. Philadelphia F. Blakiston, Son & Co. 939.
8. KETTERMAN, E. B. and LUTHERCOTT, S. W. Am. J. Med. Sc. 939, 344-353.
9. MORRIS, HENRY. Morris Human Anatomy 10th ed. Philadelphia The Blakiston Co. 94.
10. ROBERTSON, L. G. and BEAN, G. F. The Volume of the Blood and Plasma in Health and Disease Philadelphia W. B. Saunders Co. 939.

# HERNIATION OF THE NUCLEUS PULPOSUS

## As a Complication of Pre-existing Low Back Instability

EDWIN M. DEERY, M.D., F.A.C.S., New York, New York

THE object of this preliminary report is to urge the more general recognition of a group of patients in whom herniation of the nucleus pulposus is a complication of a preceding low back instability.

The relatively new entity of herniation of the nucleus pulposus has received increasing study and clarification throughout the past decade. An excellent summary of the work is given by Bradford and Spurling. The literature since that publication continues to give many further reports. While the condition is now a well established entity, it is apparent that it still presents certain unsolved aspects. With increasing recognition there are increasing numbers of patients being operated upon by the neurological surgeon. Many other patients, however, are actually being seen first by the orthopedic surgeon, because of the two complaints of low back and sciatic pain. Each specialist has in the past brought but one point of view to the problem. The viewpoints have necessarily been different. Controversial issues have not been simplified by some of the perhaps too positive statements made in each specialty.

The neurological surgeon is routinely diagnosing these conditions and operating upon such patients, and in the past at least he has been inclined to work without any routine collaboration with the orthopedic surgeon. In the uncomplicated case of herniated nucleus, the results have for the most part been very satisfactory. The patient nowadays receives a routine operation and is out of the hospital in about 3 weeks time. The good results in the majority of such cases have probably made the problem seem fairly simple. Most neurological surgeons are, however, becoming increasingly aware of the need of orthopedic help in solving some of their cases.

The orthopedic surgeon has been treating low back and sciatic pain for a much longer time. The orthopedic literature contains numerous reports of groups of patients cured of low back pain with "sciatica" by fusion. The orthopedic surgeon is rightly troubled to see certain patients who need a fusion, treated by laminectomy only. It is apparent from my own glances into the orthopedic literature that there are also several other ortho-

pedic measures that are being used to relieve low back pain with "sciatica."

It is likely, as with so many other conditions in the past, that clearer definitions and possibly the recognition of subgroups will actually simplify rather than complicate the issues. In the routine practice of neurological surgery, my own experiences with herniation of the nucleus pulposus (which form no part of the present report), have been similar to those of others. For purposes of description in this paper such uncomplicated cases of herniated nucleus will be referred to as group I. These patients give a fairly routine history. Most of their pain is sciatic pain with a minimum of low back pain. There is no outstanding preceding history of "back trouble." Orthopedic opinion in such cases is that of a stable low back and such patients require only removal of the herniated nucleus.

In my capacity as neurological surgeon to The New York Orthopaedic Hospital, however, I have had a quite different set of experiences. It leads me to urge the more general recognition of group II cases, i.e., herniated nucleus pulposus as a complication of a low back instability. I believe this condition should be looked upon as a distinct entity from the uncomplicated herniated nucleus. If this be done, many of the questions as to the need of fusion that we hear being discussed in the individual case will solve themselves. How common group II cases are, as compared with group I cases, cannot be told until many years of reports from clinics are available in such a new subject. Group II cases are not rare, however. The first series of 100 cases of patients operated upon in this hospital have now had a sufficiently long follow-up to make them a subject for a report which will follow soon, presenting both neurological and orthopedic aspects.

### DESCRIPTION OF THE GROUP SEEN AT THIS HOSPITAL

The combination of low back and sciatic pains brings increasing numbers of these patients to orthopedic hospitals. It is important to describe clearly the group of patients seen here who have proved to have the combination of both orthopedic and neurosurgical lesions, i.e., an unstable



low back requiring fusion and herniation of the nucleus pulposus as well.

These patients were primarily orthopedic cases. They had been treated conservatively in the clinic or hospital for their low back instability often for a long time. Because they proved refractory to conservative treatment, they constituted the 4 per cent of the clinic cases of this condition in which surgical fusion was advised. In this group of cases, all those complaining of sciatic pain routinely received a thorough neurological study before operation was planned. A considerable number of these patients proved to show neurological signs of a herniated nucleus. The neurological study and diagnosis, however, were secondary to the decision of the orthopedic staff for the need of fusion. Both operations were carried out together with satisfactory results.

Here then is a group of patients in whom both an orthopedic and a neurosurgical condition were responsible for their complaints. The fact convincingly establishes this combination as a quite separate group from uncomplicated herniation of the nucleus pulposus. These patients required the services of both the orthopedic and the neurological surgeons. The overlooking of either condition, numerous examples of which we have seen, almost surely means further trouble for the patient later. The recognition of combined orthopedic and neurosurgical cases is not new. Among those urging that such cases exist have been Goldthwaite Smith, Spurling and Bradford, Myster (18) and Myster and Barr (19).

Many men in both specialties have for long recognized the need in certain cases of close co-operation between the orthopedic and neurological specialists. Still lacking however is any general acceptance of this viewpoint. The general recognition of such combined cases should do much in clearing up many of the contested points on the subject of low back and sciatic pain. This combined group has in the past several years become increasingly convincing to me. From my viewpoint even the patient's history differs from the uncomplicated herniated nucleus seen in routine neurosurgical practice. Besides the relatively recent and predominant complaint of sciatic pain there is a long preceding history of low back pain and discomfort. In this special group it is my belief that herniation of the nucleus pulposus is secondary and develops after the joint instability. Failure to recognize such cases almost certainly explains some of the failures of cure that both orthopedic and neurological surgeons have experienced. The relation between a preceding joint instability and subsequent hernia-

tion of the nucleus pulposus seems quite clear in this group. No such problem appears to exist in group I, the uncomplicated herniated nucleus.

#### THE DIAGNOSIS OF HERNIATED NUCLEUS

The diagnosis of herniation of the nucleus pulposus has been greatly clarified in the past few years. How simple or difficult its recognition still remains a question as may be judged by even the most recent literature. The orthopedic surgeon, who sees many of these patients, is necessarily interested in the diagnosis of this condition.

The majority of clinicians even up to very recently have considered the neurological signs so vague that lipiodol has been generally used. From this has come many excellent special reports of the use of lipiodol in the diagnosis.

A few but very few have taken an extremely opposite viewpoint as to the difficulty of diagnosis. These would have us believe that the history alone in such cases is so typical that, with or without neurological signs, the diagnosis is simple.

My experience does not agree with either viewpoint. The diagnosis of herniated nucleus pulposus is neither particularly difficult nor simple. The lesion produces characteristic neurological signs. A careful neurological examination will accurately diagnose the presence of a herniated nucleus as well as its level, without recourse to lipiodol, in almost all cases. Lipiodol is not used in this hospital for the diagnosis.

**Neuralgia and neuritis.** Before a description of the neurological signs produced by a herniated nucleus, it seems essential to urge a more exact use of the terms "neuralgia" and "neuritis." These terms are still used interchangeably in the literature. Adding to the confusion is the term "sciatica." Sciatica should either be discarded altogether or modified to "sciatic pain," its commonest present usage.

"Neuralgia" should be used as meaning pain and pain only. Sciatic neuralgia, i.e., sciatic pain, is a complaint, not an objective neurological sign. Sciatic neuralgia cannot be recognized. It is the patient's complaint and when caused by a herniated nucleus it disappears as soon as the nucleus is removed.

Neuritis, as correctly used, implies a abnormal or retrograde changes within a nerve. It is recognized clinically by functional losses in the end organs supplied by that nerve. In the case of the sciatic neuritis produced by the pressure of a herniated nucleus on a nerve, functional losses both sensory and motor are to be found in the end organs innervated by the affected nerve. The

motor and sensory losses due to the neuritis, constitute the neurological signs that make a reliable diagnosis. Thus while the patient with a herniated nucleus complains of sciatic neuralgia, the neurosurgical diagnosis is made on the signs of sciatic neuritis. Again, with removal of a herniated nucleus the pain (neuralgia) promptly ceases to exist, whereas the motor and sensory losses caused by the retrograde changes in the nerve (neuritis), persist for many months after operation as the nerve recovers (6). For example, an absent ankle jerk may not reappear for many months after operation. If neuralgia and neuritis were used consistently and correctly in the literature it would greatly simplify interpretations of reported results.

### HISTORY

The history of herniated nucleus is that of sciatic neuralgia, that is, pain along the course of the sciatic nerve. While the history is very characteristic, it is of course not diagnostic, as some would claim. We all know that there are other causes of sciatic neuralgia besides a herniated nucleus. The complaint then is that of severe unilateral pain in the leg, experienced along the known course of the sciatic nerve. Pain along the front or lateral aspect of the leg is not sciatic pain. Generally speaking, but not invariably, the following facts hold true. The sciatic pain is increased by all back movements and by coughing or sneezing. It may or may not be improved by bed rest. It is generally unrelieved or made worse by physiotherapy. It is considerably increased when the patient bends toward the side of the pain. In the combined group seen at the Orthopaedic Hospital there is a good deal of low back pain. Moreover the story of low back pain and discomfort in this group is generally a long one, antedating the onset of sciatic neuralgia by months or years. The majority of the patients date the onset of the sciatic pain to a fall or a lifting strain.

*General features* The patient may appear to be fairly comfortable or may be first seen in a severe attack of pain. In the latter event there is generally a protective limp and the back is bent forward. There is a flat low back from loss of the normal lumbar lordosis and the lumbar spine tends to curve away from the side of the pain. This feature as well as the increase of pain experienced with bending toward the side of the lesion are probably related to changes in the size of the intervertebral foramen, Danforth and Wilson. The postural deformities of the lower spine due purely to pain and spasm are sometime marked in such cases.

*Neurological signs* The specific signs of herniated nucleus in the lower lumbar spinal canal are mild but definite. A careful neurological examination will reveal them. They are unilateral signs of mild losses in motor and sensory functions. They are caused by the retrograde neuritic changes in the nerve that is being compressed by the herniated nucleus. Either motor or sensory signs may predominate. Either, but not both, may be missing. When a number of these patients have been seen, the composite picture however is remarkably characteristic and uniform.

*Motor signs* *Muscle strength* The majority of these patients will show a little weakness in dorsiflexion of the foot on the affected side.

*Muscle atrophy* This is commonly found. In general the longer the history, the more the measurable atrophy. Careful measurements are made at 15 centimeters above and below the patellas and the affected leg will usually show a little atrophy. Atrophy of the gluteal muscle on the painful side is very often found. The mild flattening of the normal contour is very definite. Few examiners look for it.

*Reflex changes* Practically speaking, a reduced or absent ankle jerk will be found. It will generally prove true, however, that the sensory changes to be described, are a more reliable guide to the level of the herniated nucleus than are motor signs. Almost all patients have a reduced to absent ankle jerk, for example, yet the location of the herniated nucleus is not always at the fourth-fifth lumbar interspace.

*Sensory changes* Most of the patients will show characteristic sensory changes along the outer side of the lower leg and on the foot. Indeed, many patients are aware of some numbness and mention it as part of the history. Sensation should be tested first for light touch, comparing the two legs. The patient's eyes should be closed. If patients can see light touch being tested for, they will generally give less correct answers. A light rubber band or cotton should be used. Diminution of pin prick will be found in the same area where light touch is diminished or lost.

Much has been written about the discrepancies of sensory distribution shown in anatomical charts. Sensory overlap to any given area has also concerned the clinician in attempting to interpret findings. Practically, in testing these patients the following facts will prove to aid in correct diagnosis. The outer side of the lower leg as well as the outer side of the ankle and foot can be considered the area supplied by the 1st and 2d sacral nerves. If the sensory changes are limited to this area the herniated nucleus will generally

be found in the lumbosacral interspace. If in addition, there are sensory losses on the inner side of the foot, from toe to heel, which is the area supplied by the 5th lumbar the nucleus will be found at the fourth-fifth lumbar interspace. Since the majority of herniations occur at the fourth-fifth lumbar interspace (apparently quite irrespective of the orthopedic instability being oftenest at the lumbosacral level) sensory changes will usually involve the 5th lumbar and 1st and 2d sacral skin areas.

Straight leg raising, as is generally known, is apt to be limited on the painful side. The sciatic nerve is more or less tender to pressure all the way from the sciatic notch to the popliteal space. Increase of sciatic pain with coughing, sneezing may exist. This is not particularly diagnostic as some cauda equina tumors produce this complaint too.

#### SPECIAL TESTS

**X ray.** While the x ray films are of great importance to the orthopedic surgeon, they are of less help to the neurological surgeon in these cases. It has already been shown in the literature that a narrowed intervertebral space is not a reliable guide to either the presence or the level of a herniated nucleus. The herniation can occur with normal intervertebral space. This was generally true in this combined group. The orthopedic instability and narrowed intervertebral space were generally at the lumbosacral level whereas the herniated nucleus was usually found at the fourth-fifth lumbar interspace. As previously stated, sensory testing was found to be the reliable guide to the level of the herniated nucleus, regardless of the narrowed space.

**Lumbar puncture.** This test is routinely carried out in all cases. It is carried out not because the results are diagnostic for herniated nucleus but because it occasionally helps to reveal spinal cord tumor instead. There is practically no risk and little discomfort to the test. Therefore there seems no point in omitting it from the preoperative study. The spinal manometric is characteristically normal as would be expected with so small an intraspinal lesion. The cerebrospinal fluid protein reading is 50 milligrams, a slight elevation above normal. With convincing neurological signs of a herniated nucleus and a normal protein, the latter should not modify the diagnosis. There does not seem to be an entirely satisfactory explanation for the mild elevation in spinal fluid protein produced by a herniated nucleus. It is comparatively small lesion within the large lumbar canal.

**Lipiodol.** As already stated, lipiodol has not been used in this hospital for making the diag-

nosis of herniated nucleus. It has not been found necessary. I am aware of the many splendid special studies of its use in this connection, among them being those of Camp, Hampton and Robinson, Bell and Spurling.

There seems to me to be real objections to the use of lipiodol. There is a fairly general tendency to accept a negative lipiodol report despite definite neurological signs, as proof that the lesion is not present. I have operated upon a number of patients for a herniated nucleus who had been rejected for operation elsewhere because of negative lipiodol report. In each such case definite signs of herniated nucleus were present, and the lesion was found at operation. A positive lipiodol study is excellent proof of the existence of a herniated nucleus. A negative lipiodol study is not reliable proof of its absence. Unless the surgeon is willing to operate upon the basis of real neurological signs, many patients with a negative lipiodol report will continue to have their herniated nucleus and the pain it produces.

Lipiodol, despite some reports to the contrary is not entirely harmless. I have on several occasions operated upon patients who had had lipiodol injected into the spinal canal a long time before. In each instance the nerves of the cauda equina were involved in heavy connective tissue scar. Throughout the latter as dissection was carried out, numerous collections of the lipiodol were opened into. It seems obvious that in some patients, lipiodol, if left in the lumbar sac over a period of years will cause scarring and trouble. Present methods for the removal of lipiodol are not entirely satisfactory. Removal of much of the lipiodol can be accomplished. A good deal still remains, as a yone can see who will look at an x ray picture taken after such a procedure. Lipiodol, once in the lumbar sac, can sometimes travel quite far along the individual nerves. Dyle and Deery and Capener. There are occasional cases in which, after neurosurgical diagnosis in which, all other means failing, lipiodol does seem indicated. In such, I use it without hesitation, but with regret.

Attempts to demonstrate the herniated nucleus by the subarachnoid injection of air and other gases were given a fair trial some time ago in this hospital. Myelography was then abandoned as being unsatisfactory. A negative myelogram is even less reliable data than a negative lipiodol test.

#### OPERATIVE TREATMENT

When both a surgically unstable foot and herniated nucleus are diagnosed in this hospital, both operations are carried out at the same time.

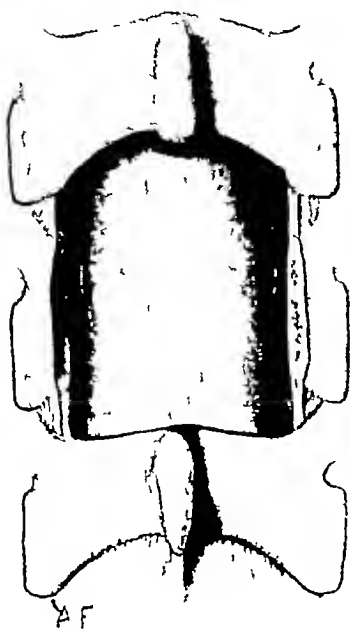


Fig 1

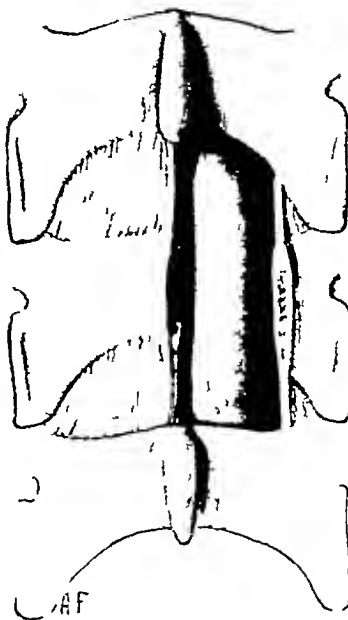


Fig 2

This is the logical procedure from all possible viewpoints. It involves only one hospitalization and one operation for the patient. There is no increase in operative risk in combining the orthopedic and neurosurgical procedures. The mortality in the first one hundred such cases in this hospital was zero. The present greatly simplified neurosurgical procedure for removal of the herniated nucleus does not offer any threat to the chances of successful fusion. Those who have had much experience in operating through a well healed fusion to get at and remove a previously overlooked herniated nucleus will appreciate the difficulties involved if the herniation is not removed at the first operation. Whenever a herniated nucleus is diagnosed before a fusion operation it should always be dealt with at the time of fusion. We have in this hospital more recently come to exploring for herniated nucleus at the time of fusion in nucleus suspect cases. When a herniated nucleus has not been definitely diagnosed but is suspected, exploration is made. We are finding a surprising number in this way. The neurosurgical exploration is sufficiently simple during a fusion operation so that we now feel it indicated in these suspected cases.

**Laminectomy** Most orthopedic surgeons are aware of the neurosurgical procedure for removal

of herniated nucleus now carried out in the vast majority of cases. The laminectomy of 10 years ago for this condition has been greatly modified. Certain of the objections held by orthopedic surgeons to the laminectomy as formerly carried out cannot be justified now. The evolution of the laminectomy for herniated nucleus should be of interest to all who come into contact with these patients.

The earlier operations were comparatively formidable procedures. Several pairs of laminae were often removed. The dura was opened and the nerves of the cauda equina retracted and search made for the characteristic bulge under the ventral dura caused by the herniation. When found, the ventral dura was opened and the lesion was removed.

With increasing knowledge and experience came the realization that the lateral position in the spinal canal of most herniations, made an extradural approach logical. It then became usual to expose the lesion by the removal of one pair of laminae (Fig 1) and without opening the dura. Hemilaminectomy (Fig 2) logically followed.

Even the sacrifice of this amount of bone was found to be unnecessary in most cases, as the herniated nucleus lies at the interspace level rather

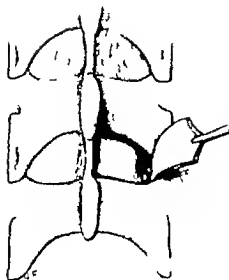


Fig. 3

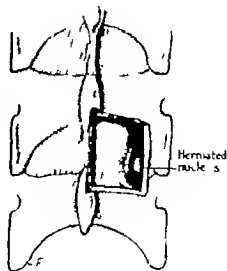


Fig. 4

than under the lamina. The present procedure in most cases consists of exposure and removal of the herniated nucleus through the interlaminar space with the sacrifice of little or no bone at all. Figure 3 shows removal of the ligamentum flavum on one side only. After the ligament is removed or reflected, the herniation can generally be felt even before it is seen. Figure 4 is a composite sketch showing a small amount of bone removed from both laminal edges. Removal of bone from one laminal edge is oftener sufficient and in many cases removal of the nucleus can be carried out without any bone being removed. Thus the present operation is comparatively simple procedure carried out between the laminae. The interlaminar space is kept at its maximum width during the procedure by having the patient's hips flexed and the legs down.

#### TYPES OF HERNIATED NUCLEUS

**Type 1** The most common type of herniated nucleus found at operation is a small round to oval mass, still covered by the overlying lateral portion of the posterior longitudinal ligament. It can generally be felt with the forceps before it is seen. It has characteristic rubbery resistance to touch. Overlying the lesion is the spinal dura and the involved nerve root. The latter is curved

upward pushed laterally and is generally somewhat flattened from the pressure of the lesion beneath. As first encountered the most prominent part of the herniated nucleus generally presents in the angle formed by the nerve root and its junction with the spinal dura as a whole. It is a natural temptation to attack the lesion in this angle. This should never be done. This angle contains more or less fatty tissue, often several small veins and is entirely too crowded to work in. Injury to the nerve is apt to result if the herniation is approached in this angle. The safest and actually the quickest method of exposing the herniated nucleus is to retract and cover the nerve root medially over the prominence of the herniation.

With the unopened spinal dura and the nerve root both retracted medially the lesion is exposed lateral to the nerve root. With incision of the overlying posterior longitudinal ligament the nuclear material is readily removed with clamp, forceps or curette. There does not seem to be any real reason for cutting deeply within the substance of the Intervertebral disc. To certain extent it seems true that the shorter the history of the patient, the softer the nuclear material. Firmer tougher nuclear material, often permitting removal in one piece with a clamp, is more often encountered in patients with a longer history of sciatic pain.

These illustrations show the bilateral exposure of the spine as seen in the combined operations. In microscopic removal of the nucleus without the need of incision, retraction of only one side of the back muscles is needed.

*Type II* Less frequent, though indeed common enough is the herniated nucleus that has already forced its way partly or wholly through the posterior longitudinal ligament. It lies directly under the nerve root almost free within the spinal canal except for a small portion beneath the ligament. This type of herniated nucleus can generally be picked up and removed in one piece with a minimum of exposure and effort. It is very easy to see and remove.

*Type III* This is the least common but the most discussed. This small almost flat lesion is often missed by some. It is pronounced no herniation at all and left untouched by others. There is a question in the minds of many who are shown this lesion in the operating room whether it is really a herniation at all. Compression of the nerve root seems negligible and the lesion is often almost flat. This type is small flat, inconspicuous and very easily missed.

The question as to whether or not this is a real herniation can be answered quite definitely. Removal of the lesion in the usual manner does cure the patient's sciatic pain. Laboratory study of the specimen proves it to be typical nuclear material. Finally, in such cases exploration of the next interspace will invariably prove negative for another herniated nucleus.

Why such a small flat lesion can produce its signs and symptoms is a more difficult question. The probable explanation seems to be that some of these lesions can and do vary in size, with different positions of the patient. We have hyperextended some of the patients as Love and Walsh have done, while the lesion has been under direct observation. I have seen enough evidence in some to believe that variations in size are possible. Ordinarily we do not take the time now to try this test. The rubbery resistance of even these small flat lesions is quite characteristic and very different from the feeling of a normal posterior longitudinal ligament with a normal intervertebral disc beneath. Unconvincing though this small type of herniation may appear in the operating room it is never a mistake to remove it.

#### THE INTERVERTEBRAL FORAMEN

Surgeons dealing with sciatic pain have long been aware of the importance of the intervertebral foramen. Naffziger, Inman, and Saunders, Ghormley and Kirklin, Hadley (12, 13), Hart, Mitchell, Ghormley and Wesson, Williams and Yglesias, and Williams. The intimate relation at the region of the foramen, of the posterior longitudinal ligament, the ligamentum flavum, and a herniated nucleus, is important to keep in mind. There

is often, particularly in this combined group with an orthopedic problem more or less thickening of the ligamentum flavum anyway. Added to this is the presence of a herniated nucleus and more or less engorgement and swelling of the involved nerve. It can be well imagined that the foramen is quite crowded. Relatively small herniations occurring far laterally can produce much crowding of the nerve. After removal of a herniated nucleus it is always worth while to curette away thickened ligamentum flavum tissue in the region of the foramen. A probe should finally be passed out along the nerve through the foramen to make more certain that no removable obstruction exists.

#### PROBLEMS IN TREATMENT

*Fusion operations and "sciatica"* The controversial points existing on this question are numerous. From the neurosurgical viewpoint certain remarks seem justified. The question of fusion for low back pain and sciatica is of course a purely orthopedic problem. It is urged, however, that the orthopedic writer should define the general term "sciatica." If the cures of sciatica by fusion reported in the literature mean cures of sciatic pain (sciatic neuralgia), no question can be raised from the neurosurgical viewpoint. If, however, the term "sciatica" implies the presence of a herniated nucleus a major question can be raised. As emphasized earlier, the diagnosis of a herniated nucleus is made on the basis of convincing signs of the sciatic neuritis caused by the pressure of the herniated nucleus. Sciatica, sciatic neuralgia, or sciatic pain are no convincing proof of the presence of a herniated nucleus. The reports of cures of sciatica in the literature do not definitely state that herniated nucleus pulposus is present. The implication, however, is often that it is. Completely lacking in such reports is any detailed neurological data in proof that a herniated nucleus is present. It is not questioned that sciatic neuralgia of various types responds to appropriate orthopedic measures as reported in the literature. The often raised question as to whether fusion alone can relieve sciatic pain is a very different question therefore from whether fusion alone can relieve the symptoms of a herniated nucleus. We all see cases of sciatic neuralgia in which there is no suspicion of herniated nucleus.

*Fusion for herniated nucleus* Will the immobilization provided by fusion relieve the patient with a real herniated nucleus? The number of patients coming to this hospital for relief of herniated nucleus who have previously received a fusion

points otherwise. Relief of their sciatic neuralgia and recovery from sciatic neuritis come only after the herniated nucleus is removed.

The appearance of the flattened, tense nerve stretched over the usual herniation seen in the operating room, suggests that no operation other than removal of the mass beneath could give relief to that nerve. It is difficult to see how fusion alone can provide any relief to such a nerve. Removal of the herniated nucleus at the time of fusion is a relatively simple procedure. Removal later through a solid fusion is quite difficult. When herniated nucleus has been definitely diagnosed, fusion alone is incorrect and almost surely will mean further surgery for the patient later.

**Fasciotomy.** The number of patients showing definite evidence of a herniated nucleus who have previously received a fasciotomy operation calls for comment. In these patients the fasciotomy had failed to relieve their sciatic pain. It is difficult to imagine why that operation should relieve the pain caused by a herniated nucleus nor was the operation designed for this condition. The fasciotomy may have been carried out before convincing signs of herniated nucleus were present. I think it is obvious that neurological signs, present for long, had been overlooked. A neurological examination should be called for, rule out herniated nucleus before fasciotomy operations.

#### CONCLUSION

In addition to uncomplicated herniation of the nucleus pulposus it is apparent that this condition does occur as a complication of low back instability. A more general recognition of such combined problems than exists at present is needed. Adequate handling of such combined problems requires the services and close co-operation of both orthopedic and neurosurgical specialties. Such patients require combined operations to solve

their problem adequately. It is believed that when both conditions exist, they both must be recognized and treated together to insure the speediest possible recovery.

#### REFERENCES

1. BILL, J. C. and SPURLING, R. G. *Radiology* 1919, 31 473-480.
2. BRADFORD, F. K. and SPURLING, R. G. *The Lower Vertebral Disc*. Baltimore, Md. Charles C. Thomas 1934.
3. CAMP, J. D. *Proc. Mayo Clin.* 1937 373-377.
4. CAPPELLEN, N. *Proc. R. Soc. Med.* 1937 30 262-263.
5. D. CRYSTAL, M. S. and WILSON, P. D. *J. Bone Surg.* 1934, 16 60-66.
6. DEERY, E. M. *Textbook of Pathology*. DeBakey & Fredeen 6th ed. p. 2. Baltimore: William Wood & Co. 1936.
7. DYER, C. G. and DEERY, E. M. *Bull. New Inst. N. York.* 1937, 303-309.
8. GROMBLY, R. K. *J. Am. M. Ass.* 1934, 91 772-777.
9. GROMBLY, R. K., and KIRALIN, B. R. *Am. J. Roent.* 1934, 3 75-76.
10. GROMBLY, R. K., and WILSON, H. R. *South M. J.* 1937 30 806-8.
11. GOLDSTEIN, J. E. *Boston M. & S. J.* 9 44 365-372.
12. HADLEY, L. A. *J. Bone Surg.* 1936, 8 428-433.
13. Idem *J. Am. M. Ass.* 1934, 875-878.
14. HUNTER, A. O. and ROSSWORTH, J. *M. Am. J. Roent.* 1934, 30 783-803.
15. HALL, V. L. *J. Lancet.* 1935 35 309-311.
16. LOVE, J. G. and WILSON, M. V. *J. Am. M. Ass.* 1934, 306-309.
17. MITCHELL, C. L. *J. Bone Surg.* 1934, 6 706-708.
18. MITCHELL, W. J. *Ann. Surg.* 1937 66 777-781.
19. MORTON, H. J. and BAKER, J. B. *N. England J. M.* 1934, 10-11.
20. NAPPEN, H. G., M. V. and SUTHERS, J. B. *C. M. Surg. Gyn. Obst.* 1934, 66 334-350.
21. SMITH, A. A. *DeForest Surg. Clin. N. America.* 1934, 9 473-490.
22. SPURLING, R. G. and BRADFORD, F. K. *J. Med.* 1934, 9 597-605.
23. WILLIAMS, F. C. *J. Bone Surg.* 1937 9 343-363.
24. WILKINSON, P. G. and WILKINSON, L. *J. Bone Surg.* 1934, 3 379-390.





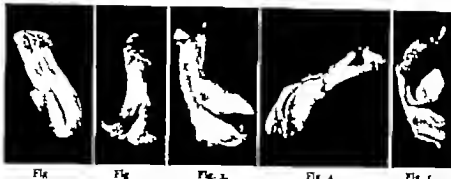


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 1. An early longitudinal split in the body of the posterior cartilage.

Fig. 2. A split has extended to the posterior pole with slight displacement.

Figs. 3 and 4. Splits with pronounced displacement.

(The tear in the mid portion of the meniscus in Figure 4 is an artefact.)

Fig. 5. A posterior split which has been torn loose from the posterior pole so that the central portion forms a tab with its attachment to the middle third of the meniscus.

of the middle one-third, found in 3 cases and (c) hypermobile menisci found in 5 cases.

There is little doubt that in a number of cases in this second group there will be a considerable portion of the disturbing element left in the joint if only the anterior two-thirds of the cartilage and its associated bucket-handle tears are removed. This is particularly true in cases of long standing injuries in which multiple lesions in different stages of healing are present. It is impossible to tell which case has a simple single tear. The arthritis found in joints with old meniscal lesions is often the result of such an oversight. Tears in the middle third fall in the same category. Hypermobile menisci should be totally removed because they usually reveal degenerative changes extending throughout, which form the basis of future tears, and because it cannot be determined by inspection through the operative incision alone that there is not a tear in some portion. Elderly, sedentary patients form the exception to this view.

**Group 3. Total excision is controversial** in the case of lesions limited apparently to the anterior half of the meniscus, such as avulsion of the anterior attachment, avulsions from the coronary ligament, splits, and tabs. Such lesions were found in 37 of our cases. Visualization cannot always be relied upon since it is shown by one case mentioned in group 1 that isolated tears in both the anterior and posterior portions may exist simultaneously. Good judgment on the part of the surgeon is essential in these cases. Some surgeons may approve of the removal of only the anterior two-thirds of the meniscus if trauma does not appear extensive and is localized to the most anterior aspect of the joint. However in the light of our experience we are of the opinion that

complete removal of the meniscus is necessary since such lesions as represented in Figures 1 to 4 clearly demonstrate how a hidden pathological process may exist in the posterior element. Complete excision is the logical course if there is considerable evidence of trauma or the tear extends past the anterior third.

**Group 4.** In this group of 3 cases no pathological process was discovered. When no pathological lesion is visualized it is best to excise the meniscus on the basis of symptoms alone. The frequent discovery of tears in the posterior horn after total excision in cases in which there was no gross change on examination through the anterior approach is the basis of this concept. Typical examples of this type of lesion are shown in Figures 1 to 4.

In our opinion, it is better in a symptomatic knee to excise a normal cartilage totally rather than to risk overlooking a posterior tear. It is generally recognized that such a procedure is not attended by any more residual disability than occurs with simple arthrotomy.

In summary we believe that the entire meniscus should be removed in all cases in which the clinical examination has led to diagnosis of meniscal injury. This includes those cases in which arthrotomy performed for other conditions such as osteochondritis dissecans, etc., reveals unsuspected coexisting lesions of the semilunar cartilage. Residual symptoms frequently arise from degenerative changes in the articular cartilage and synovia which follow incomplete removal of lacerated meniscal fragments.

#### DIAGNOSIS

There are two diagnostic aids in the proper operative examination for derangement of the pos-

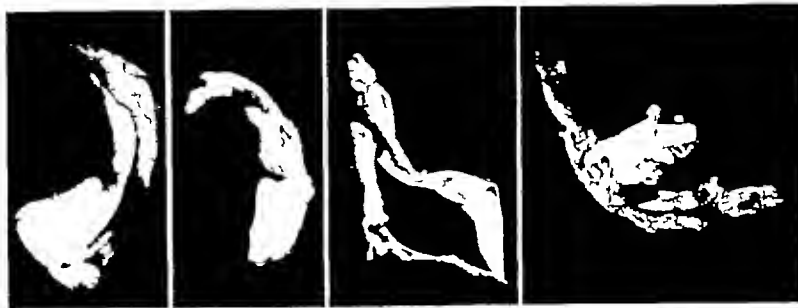


Fig 6

Fig 7

Fig 8

Fig 9

Fig 6 A posterior angle tear in a relatively early stage. This type will not give a positive posterior click sign. Note that the tear originates from the central border tending to refute the hypothesis of Bristow that tears in the menisci are all primarily longitudinal.

Fig 7 A later healing stage of the posterior angle tear.

Fig 8 Complete bucket handle tear, including the whole posterior horn. Note the secondary pathological lesion in outer portion.

Fig 9 An old injury of the meniscus with multiple tears in different stages of healing.

terior meniscal elements first, tenderness posterior to the collateral ligament, and second, the presence of a posterior click. The latter requires some explanation. Its presence has been recognized for several decades, although not generally employed in routine orthopedic examination. In his classical monograph on internal derangements of the knee, Fischer states "Displacement of the posterior horn of the external semilunar cartilage, by no means a rare occurrence, is probably due to internal rotation of the femur on the fixed tibia, followed by, or combined with, violent flexion. It is one of the causes of the peculiar condition known as clicking or snapping knee, the last 20 or 30 degrees of extension being accompanied by a click and jerk forward of the tibia." In reference to the medial meniscus, McMurray states "as the leg is brought from the position of acute flexion to full extension, a click may appear in the joint but usually the click is so slight that no notice is taken of it." Watson-Jones has re-emphasized the value of this test in his recent textbook.

The posterior click test is accomplished as follows. With the patient lying on his back and the examiner standing by his side, the knee is placed in full flexion. One hand locates the joint line and the other firmly grasps the foot. The tibia is first internally and externally rotated, and then abducted and adducted. Following this, it is forced into external rotation and extended, and then placed in internal rotation and extended. At some time during the course of this maneuver, a click is felt and frequently heard in the joint line posterior to the collateral ligament. This must be differentiated from the crepitant, grating sensation, of a synovitis. The patient will describe the sensation as a "slipping" or "pop" in the middle

of the joint. Frequently, when the click cannot be heard audibly, it can be demonstrated by the stethoscope. The click is usually best demonstrated in the medial meniscus on external rotation and extension from the fully flexed position, and in the lateral meniscus by internal rotation and extension. No correlation between the degree of extension and the position of the tear could be demonstrated.

In 71 cases in which this test was made a part of the routine examination, it was found to exist in 15 (21%). In each instance, a lesion was found in the posterior horn of the cartilage. It may be said therefore that in this limited experience the "posterior click" is significant of posterior horn lesion. This does not mean that there is no other pathology in the meniscus, but simply that the posterior segment is involved. This sign was found in association with complete bucket-handle tears, and in bucket-handle tears in which there were secondary posterior splits and rupture of the mid-portion of the bucket-handle fragment, as well as complete avulsion of the posterior horn from the coronary ligament. It was also present in one case of bucket-handle tear in which there were no other clinical signs present. The fact should be stressed, however, that posterior horn lesions can exist in cases in which no "posterior click" is elicited.

#### RATIONALE OF SURGICAL TECHNIQUE

The short anterior-medial or anterior-lateral incision is the approach of choice for removal of the entire meniscus. It can easily be extended into the long parapatellar utility incision if associated pathological changes are found in the joint. There is no objection to the use of any of the

specialized approaches by those who can uniformly make an exact diagnosis of isolated meniscus lesion.

The problem of freeing the posterior portion of the meniscus frequently arises. In the technique used by the writers, the knee is placed over the end of the operating table flexed to 90 degrees. In the relaxed type of knee the excision may usually be done by dissection with knife and scissors with little difficulty. Removal is frequently facilitated by freeing the posterior attachment through the intercondylar notch so that the posterior rim of the meniscus is exposed when it is drawn to the side of the joint under moderate tension. Gentleness is encouraged throughout, and avulsion of the posterior portion by the blind use of strong traction is to be discouraged.

If the knee is "tight," there are two alternate methods of freeing the posterior elements. One is exposure through the Henderson incision. This enters the posterior compartment between the hamstrings and the posterior aspect of the joint. The second is the use of the tenotomy knife subcutaneously to free the posterior rim. It is performed as follows: The knife is inserted at the posterior medial or lateral aspect of the joint one-half inch above the articular surface of the tibia to insure that the blade will enter above the level of the meniscus. With traction on the cartilage, the meniscus-synovial junction is determined by placing the blade on the meniscus and moving it posteriorly until it drops in the soft synovial tissue. The cartilage is then separated from the synovium at this point and luxated into the intercondylar notch where it is amputated. This method requires a certain degree of proficiency in that it is blind. It is not easily accomplished by the inexperienced. In only 4 of 8 cases was it necessary to use the Henderson approach. The use of the Lowe-Breck and Dunlap knives, although not employed by the writers, may be of considerable advantage in the hands of the experienced.

The anterior-medial incision is used in cases of reoperation for posterior horn lesion. This is done since in practically all cases another surgeon has performed the first operation. Exact records are usually not a reliable and associated pathological lesions can be determined only by visualization in most instances. Inspection includes not only the usual search for changes in the articular car-

tilage and synovia, but also special situations. In one case for example only the anterior third of the meniscus had been resected, leaving the fragmented posterior two-thirds in its usual position. In another case the bursa between the tibial collateral ligament and synovia had become chronically irritated although the meniscus had been previously excised. With swelling the synovia with its thickened fibrous edge had been forced between the joint surfaces to produce a pseudo-locking. In a third instance in which a lateral meniscus had been previously excised in its anterior two-thirds, the popliteal tendon had luxated into the joint at the posterior lateral angle where it is usually in contact with the meniscus. Excision of the cartilage and the popliteus tendon from its point of origin on the lateral femoral condyle to the posterior joint line gave relief of symptoms. Lastly the fibrocartilage which is formed from the synovial edge following surgical removal of the cartilage may itself be cause of disability especially if it has been formed from redundant synovia.

#### CONCLUSIONS

1. Lesions of the posterior meniscus frequently exist both alone and in association with tears of the rest of the cartilage.
2. The presence of a "posterior click" immediately behind the collateral ligament is evidence of posterior horn pathology.
3. Absence of this sign does not eliminate posterior horn pathology.
4. The entire cartilage should be removed routinely in all cases.
5. The technique and rationale of surgical excision of the meniscus as practiced by the writers is presented.

#### REFERENCES

1. BRIDGES, W. R. *J. Bone Surg.* 915, 7, 605.
2. DUNLAP, KNOX. *J. Bone Surg.* 942, 24, 920.
3. FISCHER, A. G. T. *Internal Derangements of the Knee.* New York: The Macmillan Co. 924.
4. LOWE, F. V. and BRECK, L. W. *J. Bone Surg.* 934, 30, 30.
5. McILM, R. T. P. *The diagnosis of internal derangements of the knee.* Robert Jones Orthopaedic Volume. New York: Oxford University Press, 919.
6. SMITH, S. A. *Sidelights on knee joint surgery.* Robert Jones Orthopaedic Volume. New York: Oxford University Press, 925.
7. WILSON, JOHN, R. *Fractures and Other Bone and Joint Injuries.* Baltimore: The Williams & Wilkins Co. 941.

# TEN YEARS' EXPERIENCE WITH RIBBON GUT IN UROLOGICAL SURGERY

OSWALD S. LOWSLEY, A. B., M. D., F. A. C. S., New York, New York

IT is just 10 years ago that Mr. William P. Didusch, the great urological artist, suggested the use of untwisted catgut as a material for the repair of wounds in the kidney. In experiments upon animals this material proved so successful that it was promptly tried on human beings, and its use here was so satisfactory that it is now employed by us universally in many types of operations upon various organs. We have found it a most important addition to our armamentarium wherever we deal with delicate tissues.

Our animal experiments quickly proved that properly moistened ribbon gut (which contains one sixth the amount of catgut in a No. 2 catgut ligature) could be tied firmly without breaking or tearing, and that it did not cut through delicate or friable tissues. Also, it had the marvelous property of permitting fibroblasts to grow between its fibers so that, as the latter were absorbed, the fibroblasts replaced the entire structure, as shown in many of our microscopic specimens. This is a logical thing to happen because this material is an animal membrane, and hundreds of our specimens show that fibroblasts never fail to replace the ribbon gut (Figs. 1 to 4).

## RIBBON GUT IN THE REPAIR OF KIDNEY WOUNDS

*Nephrostomy.* We experimented first with the use of ribbon gut in the repair of kidney wounds. The material used consisted of flat ribbons of untwisted gut, 25 to 65 centimeters long, 1.8 to 2.0 centimeters wide, and of the thickness of fine rice paper. The gut is sterilized by heat in the usual type of aseptic catgut tube, and is unaffected by age, climate, or light. Before it is used, ribbon gut should be immersed in warm sterile water or saline solution for about 10 minutes to render it soft and pliable. Unlike the spirally twisted strands of surgical catgut which lose tensile strength by too long an immersion, ribbon gut is not injured by prolonged wetting. In animal experiments it has been used in bands of one half of the standard width (about 0.8 cm.), in operations

upon humans the full width has been used. It is tied in the same manner as are ordinary types of catgut, the width of the material does not interfere with adequate knots, and the tape shows a tendency to twist only over a distance of about a centimeter immediately adjacent to the knot.

A series of animal experiments was first carried out upon rabbits, and served to demonstrate the practicality of the method. However, the rabbit's kidney is so small that it was deemed advisable to use larger animals, consequently dogs were used in the second series of experiments, and proved entirely satisfactory. Postmortem specimens of animal kidneys showed conclusively that wounds and incisions repaired in this manner heal perfectly and that there is no destruction of kidney substance such as one sees when needles are passed through cortical tissue in the usual way.

The first nephrostomy upon a human being, in which closure by the ribbon gut technique was used in our department was done on February 15, 1933 for the removal of renal calculi, and nephrostomy with closure by this method has been used by us ever since.

The technique of operation is as follows. The kidney is exposed and mobilized through the usual lumbar incision. When the operation is for the removal of a calculus, the incision into the kidney is usually made in either the upper or the lower pole, preferably on the lateral convex border so as to avoid the vessels as much as possible. Almost any renal stone can be removed through a polar incision, and this type of wound is more easily repaired than a central cortical incision.

With the kidney completely exposed, ribbon gut which has been threaded into the Lowsley ribbon gut needle (a flat, slightly curved, spear pointed needle with cutting edges), is fixed in the proper position by passing it through the fibrous capsule of the kidney on the anterior and posterior surfaces. An incision is then made into the renal cortex between the two capsular straps, hemostasis being secured by manual pressure over the renal pedicle applied by an assistant. The calculus is located and extracted with forceps. A drainage tube is inserted through the wound into the kidney pelvis. A piece of fat is placed in the wound for hemostasis and held in position while

From the Department of Urology, James Buchanan Brady Foundation of the New York Hospital. The experimental work in developing the use of ribbon gut in surgery was made possible through grants from the Davis & Geck Research Fund of the Brady Foundation, New York Hospital.



Fig. 1

Fig. 1. Definite evidence of fibroblasts growing into the tendril of ribbon gut tied around the kidney.

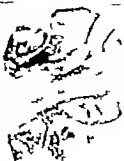


Fig. 2

Fig. 2. Ribbon gut tied around the kidney entirely replaced by fibrous tissue.



Fig. 3

Fig. 3. Showing definite evidence of fibroblasts replacing ribbon gut in rectal position.

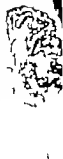


Fig. 4

Fig. 4. Replacement of ribbon gut by fibroblasts around the urethra.

the ends of the ribbon gut are tied over it with just enough pressure to approximate the edges of the wound. The kidney is replaced in the renal fossa. Penrose drains are placed down to the site of the nephrostomy, and the wound is closed in the usual manner. Interrupted dermal suture of silk holding the nephrostomy tube in place at the posterior angle of the wound (Fig. 5).

To date, 203 nephrostomies have been performed at the Brady Foundation in the New York Hospital, by the fat and ribbon-gut method of closure. Bleeding has occurred in a cases, but in all the others the nephrostomy wound healed promptly and well, with no complications.

**Calyceal Resection.** During the past 7 years, at the Brady Foundation, selected cases of primary and recurrent calyceal stones have been treated by resection of the stone-containing calyx (usually the inferior calyx) together with a wedge-shaped piece of kidney parenchyma, repair of the kidney wound being by the ribbon-gut fat technique. In 1940, Twining reported 10 clinical cases, and in September 1941 Luck and Forsythe presented further follow-up on these 10 cases, as well as 9 new cases and data obtained from experimental calyceal resections performed on 3 dog kidneys. The 9 operations upon humans resulted in 6 cures and 3 failures. The 6 cured patients all showed prompt healing and minimal infection. Even though in several cases, rather large wedge of tissue was removed there was little decrease in kidney function, as shown by a comparison of the preoperative and postoperative urea and phenolsulfonphthalein determinations.

The calyceal resection is performed as follows. The kidney is exposed through the usual lumbar incision and carefully delivered, the ureter pelvis and renal pedicle being gently freed from the surrounding areolar tissue. A wedge-shaped section of cortical and medullary tissue, containing the involved calyx and the stone, is removed in a radial manner in order that the interlobular blood vessels in the remaining parenchyma will be injured as little as possible. The surgical defect is approximated over a small piece of fat by ribbon gut sutures placed through the fibrous capsule in the manner just described (for nephrostomy). A large nephrostomy tube is placed in the renal pelvis, and a No. 8 or 9 F splitting ureteral catheter is bluntly inserted through a separate nephrostomy opening, approximation by suture usually being unnecessary. The wound is closed in layers with drainage. The ureteral catheter is removed at the end of a week, and the nephrostomy tube 3 to 5 days later. The latter is irrigated only when necessary to secure good drainage.

**Heminephrectomy.** We have also frequently performed heminephrectomy with closure of the wound as here described. The efficacy of this method has made it possible to remove cysts, as well as the diseased half of a horseshoe kidney or the diseased portion of either an anatomically normal or a double kidney (except in cases of tumor or tuberculosis).

In an anatomically normal kidney we perform heminephrectomy as follows. After the kidney has been exposed and delivered, the line of incision is decided upon. Ribbon gut is then placed through

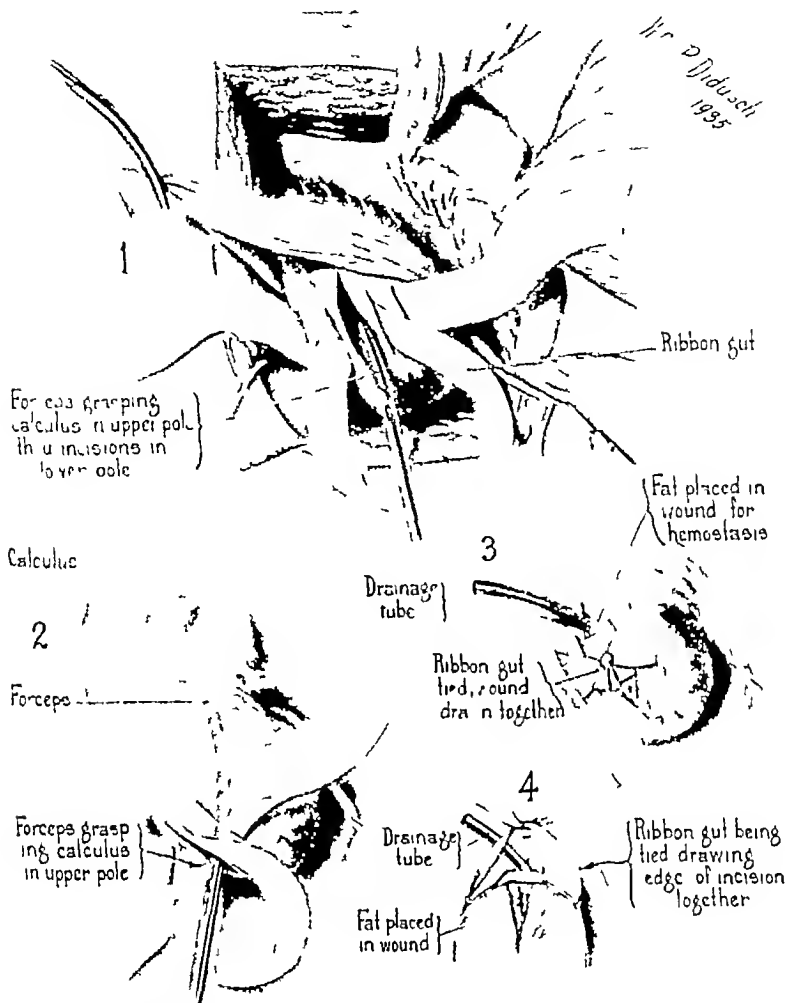


Fig 5 Nephrostomy by the ribbon gut method 1, One calculus has been removed from the lower pole and a second is being extracted from the upper pole through the lower pole incision Ribbon gut has been placed in position through the fibrous capsule of the lower pole The upper pole is bound down by adhesions from a previous operation 2, Transparent view, showing the forceps grasping the calculus in the upper pole 3, A drainage tube has been placed in position, a pad of fat inserted in the wound for hemostasis, and the ribbon gut tied over it 4, The placing of the drainage tube, fat, and ribbon gut (From *Clinical Urology*, by Lowsley and Kirwin)

the fibrous capsule, behind the line of incision, on both the anterior and posterior surfaces, and the ends of the gut are tied and left hanging free The diseased portion of the kidney is excised in such a manner as to leave a shallow V-shaped wound, with the apex of the V toward the center of the organ Bleeding is controlled by an assistant grasping the pedicle between his thumb and forefinger A piece of fat is buttered over the cut surface and the ends of the ribbon gut are tied

together over it, approximating the edges of the wound and exerting enough pressure to control bleeding but not enough to cause necrosis or tearing of the fibrous capsule The kidney is replaced in the renal fossa and the wound is closed in the usual manner with drainage

In a double kidney, the distribution of the vascular supply must be carefully determined since the halves often have separate blood supplies The site of the heminephrectomy is then

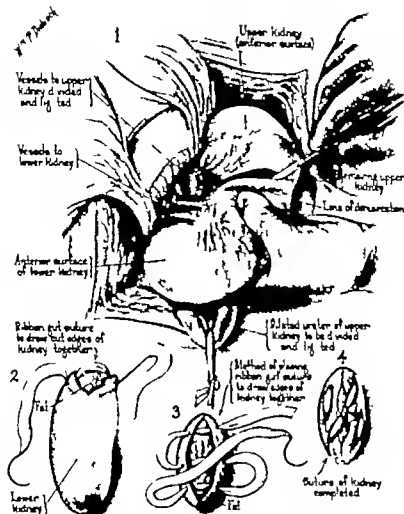


Fig. 6 Heminephrectomy in double kidney. Its repair by the fat and ribbon gut method. This patient, 3 years old, has a horseshoe kidney and ureter on the left side, the ureter of the upper segment emptying into the vaginal vestibule. She had had urinary incontinence since birth. Excising the upper segment of the double kidney after ligation and division of the ureter. The arterial supply to this segment is furnished by a branch from the main renal artery. 1, 2, 3, 4. Steps in the placing of the ribbon gut for repair of the kidney and insertion of fat for hemostasis. (From Lowrey and Courry (1931))

decided upon ribbon gut is placed in position through the fibrous capsule, and the diseased segment is excised by making a V-shaped incision into the healthy portion, hemostasis and repair being accomplished as described. About 2 years ago we thus removed the upper half of double kidney whose ureter emptied into vaginal vestibule. Excretory urograms a year later showed excellent function of remaining segment (Fig. 6)

In a horseshoe kidney after exposure of the kidneys the aberrant blood vessels (which are always present) are tied off the upper pole of the diseased half of the kidney is freed, and its ureter is ligated and excised. The isthmus is then identified and freed and the diseased half of the fused kidney is excised by making a V-shaped incision into the isthmus, its apex being directed toward the sound half. The isthmus is repaired

with ribbon gut placed through the fibrous capsule, a piece of fat being held in the wound while the gut is tied over it. Penrose drains are placed down to the isthmus and the wound is closed in the usual manner.

*Repair of Ruptured Kidney* During the past 10 years we have utilized the fat and ribbon gut method of repair in numerous cases of traumatized kidneys—a type of injury that is increasing, due to the growing number of automobile accidents.

Experimental work by various investigators has made possible a better understanding of the mechanism of renal trauma and more effective repair of such injuries. Experimentally and by clinical observation we have proved that great destruction of the kidney may take place without primary rupture of the fibrous capsule. Pulpefaction of much of the cortex may occur without perirenal infiltration of blood or urine until some time after the initial trauma, when ferments released by laceration of the cortex have digested the capsule.

All surgeons recognize the difficulty of selecting the proper cases for immediate operation. Because remote partial or complete destruction of the renal parenchyma, following traumatism, has such grave results in the form of contracted kidney with elevation of blood pressure, stone formation, cystic degeneration, etc., we believe that an exploratory operation under our modern aseptic surgical technique is advisable in most instances. If hematuria continues for more than 24 hours, or if there is no hematuria but there is evidence of extravasation in the excretory urogram, or if there is evidence of hemorrhage as indicated by a tumor in the loin, rigidity, shock, and the findings of blood examination, exploratory operation should be done immediately. Animal experimentation and clinical observation of human cases have convinced us that early operation, evacuation of blood clots, and the production of hemostasis by the fat and ribbon gut method will be followed by less destruction than is the case if the renal traumatism is untreated. Even greatly traumatized kidneys may be successfully repaired by this method.

The kidney is exposed in the usual manner and isolated. Even if the fibrous capsule is intact, the site of the injury can usually be easily seen and felt because the capsule will be elevated over the underlying hematoma. The capsule is opened, blood clots are sponged away, and isolated fragments of lacerated renal parenchyma are removed. Bleeding is controlled by applying bits of fat, which are held in position by ribbon gut passed through the fibrous capsule and tied around the

kidney and over the injured area with sufficient pressure to control the hemorrhage. A drainage tube is inserted into the renal pelvis before the ends of the gut are tied, Penrose drains are placed around the kidney, and the wound is closed in the customary manner (Fig. 7).

From examining the kidneys of experimental animals at varying lengths of time after trauma of different degrees had been inflicted upon them, it was found that in no case in which the renal capsule was opened and bleeding was stopped by fat held in place by ribbon-gut sutures, was a kidney destroyed. In even the most extensive injuries, the kidney, observed microscopically, showed actively functioning tubules and glomeruli right at the edge of the reparative scar tissue. This would seem to indicate that the only damage sustained by the renal cortex was that due to the original traumatism, and that there was no damage due to subcapsular pressure, such as one sees in a kidney not treated by opening of its capsule, evacuation of the clots, and stopping of hemorrhage. None of the animals thus treated died, and their convalescence was rapid and satisfactory. No digestion of the renal elements could be distinguished in the damaged areas. Those kidneys which were most severely injured showed marked contraction due to the formation of scar tissue, but in even the most contracted organs the renal elements were undamaged between the scars. On the other hand, failure to open the renal capsule when the kidney has been ruptured results in much fibrosis and some hyalinization. Several of our traumatized dog kidneys thus treated showed a focus of calcification in a pyramid, beneath the mucosal lining, bearing out Randall's recent theory regarding the production of certain kidney stones.

#### THE USE OF RIBBON GUT IN NEPHROPEXY

A properly performed nephropexy is, we believe, productive of highly beneficial results in carefully selected cases. At the Brady Foundation, during the past 10 years, we have had excellent results in a large number of cases with the ribbon gut method. Chromic ribbon gut, studded at each end with an atraumatic needle, is used.

A series of 12 experimental operations on dogs was performed as a preliminary to the use of this material in humans. The results of the animal experiments were so gratifying that nephropexies were done upon human beings with very slight modification of the technique.

The kidney is exposed through the usual lumbar incision and freed from the surrounding structures by separating adhesions and other clinging tissues



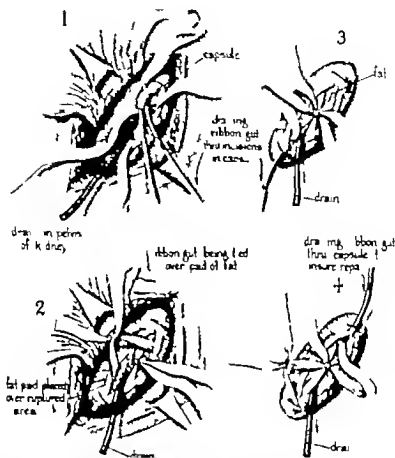


FIG. 7. Repair of ruptured kidney by the use of ribbon gut. 1. The fibrous capsule has been incised, blood clots have been sponged away, and isolated edges of damaged cortical tissue have been removed. Ribbon gut is being drawn through the fibrous capsule. A drain is passed into the kidney pelvis. 2, 3, 4. A pad of fat is placed over the ruptured area to control bleeding, and the ribbon gut is tied over the fat. (From *Clinical Urology* by Lowrey and Kibben (14).)

The fibrous capsule is incised in the midline and stripped back, thus exposing about one sixth of the kidney's surface. Chronic ribbon gut is fixed around both the upper and lower poles of the kidney by passing it through the fibrous capsule. The gut must be tied tightly enough to hold firmly but not so tightly that it compresses the cortical substance. The free ends of the upper and lower strands are then tied together which helps to hold the two slings firmly in position and forms a basket-like support for the organ. The needle-studded end of the upper-pole strand is inserted through the eleventh intercostal space as far back as possible drawing the kidney with its partly denuded cortex, up to the body wall. The

kidney must be drawn high enough so that the freed ureter is straight and slightly stretched. The needle is then cut away and the end of the ribbon gut is tied to the end which had previously been tied to the lower strand of gut. The needle-studded end of the lower-pole sling is passed through the quadratus lumborum muscle the needle cut away and the end tied to the end which has been tied to the upper strand. After it is made certain that there is no obstruction of the ureter the wound is closed in the usual manner without drainage.

Eighty-three such operations have been done at the Brad Foundation. There have been no deaths in the series, so it is impossible to tell

anything about the condition of the kidney in the human. The dogs' kidneys examined, however, all showed excellent results, and we have every reason to believe that no damage has been done to the kidneys of the humans thus operated upon. In cases followed up, the pyelograms indicate that the kidneys elevated by this method have all stayed in place, and the patients have been relieved of the symptoms complained of.

#### LIGATION OF THE RENAL PEDICLE WITH RIBBON GUT IN NEPHRECTOMY FOR TUBERCULOSIS

Occasionally in nephrectomy for tuberculosis the vessels of the kidney are so diseased that an attempt to tie them off with twisted catgut or other ordinary suture material will result in the ligature cutting through the diseased vessels. This is a serious accident as the pedicle is thereby shortened and, in many instances, it becomes necessary to leave clamps on.

After a series of animal experiments in which the kidney pedicles were tied off with ribbon gut, we successfully utilized this method to tie off the pedicle in a number of cases of tuberculosis of the kidney with disease of the vessels in human beings. In no case did the ribbon gut ligature cut through. However, caution is necessary to insure that the knot is tied tightly and not allowed to slip. A sizable rosette of tissue distal to the location of the ligature will aid in keeping the vessels intact.

#### TOTAL PROSTATECTOMY, WITH RIBBON TECHNIQUE

Ribbon gut has been found to be most useful in performing total prostatectomy by the method described by Lowsley and Kilgore in 1941.

The patient is placed on the operating table in an exaggerated lithotomy position, and a Lowsley curved prostatic tractor is passed into the bladder and its blades are opened. An arcuate incision is made in the perineum, about 1 inch above the mucocutaneous junction of the anus, thus exposing the subcutaneous fat and the central tendon. The latter is isolated from the fatty areolar tissue on either side by blunt dissection. The central tendon is then carefully incised down to the wall of the rectum, which allows the transversus perinei muscles to be retracted anteriorly. The rectum is dissected away from the overlying areolar tissue until the rectourethralis muscle is exposed. This muscle is then incised or retracted laterally, thus allowing the rectum to be dissected away from the base of the prostate. Denonvilliers' fascia is thus exposed from the apex of the prostate to the fascia covering the seminal vesicles. At this point, a transverse incision may be made in the fascia covering the

vesicles, which permits greater mobility of the gland later in the procedure.

A transverse incision is then made through the urethra at the apex of the prostate. The curved prostatic tractor is removed and the Lowsley static urethra into the bladder and opened. When the tractor is depressed downward, the anterior commissure is exposed. The anterior surface of the prostate is carefully separated from the overlying tissue by blunt dissection, thus bringing into view the anterior margin of the vesical orifice. The lateral surfaces are next separated from the surrounding structures by blunt dissection.

After the prostate has been mobilized down to the wall of the bladder, the anterior commissure is divided in the midline, exposing the vesical orifice and the prostatic urethra. A transverse incision is then made in the prostatic urethra, just distal to the internal sphincter. If the lateral lobe intrusion is so marked that the internal sphincter cannot be visualized, a midline incision may be made through the floor of the prostatic urethra, dividing the posterior and median lobes of the gland. This bisects the entire prostate up to the vesical orifice, and by exerting lateral traction on either half of the gland, good vision is obtained. The prostate may now be freed from the floor of the vesical orifice on both sides under direct vision and with a minimum of trauma to the internal sphincter. As the dissection proceeds downward, a group of vessels will be found entering the gland from each of its lateral aspects, these are tied off and cut, thus preventing the excessive hemorrhage which results when this ligature is not placed on each side.

Bisecting the prostate gland allows good exposure of the seminal vesicles, so that these may be easily removed, or clamped and ligated with the vasa deferentia and the accompanying blood vessels. Bleeding vessels are easily clamped and ligated. A Foley catheter is passed through the urethra and into the bladder.

The cut end of the membranous urethra and the bladder neck are now separated by a considerable space which formerly was occupied by the prostate gland. These two structures are approximated as follows. A suture of untwisted chromic catgut is inserted into the left lateral wall of the urethra, then through the anterior lip of the bladder orifice on the left side, and through the posterior lip of the bladder orifice. It is then carried across the apex of the trigonum vesicae and inserted into the posterior lip of the bladder orifice, on the right side, the anterior lip of the bladder orifice, and through the right lateral wall

of the urethra. The bladder is drawn to the urethra, which is fixed with an Alha clamp and the ribbon gut suture is tied thus plicating the bladder orifice and the urethral wall—all with one suture. A second ribbon-gut suture is inserted into the left wall of the urethra, carried over the apex of the trigonum and through the right wall of the urethra, and is then tied, thus reinforcing the first plication suture.

The Foley catheter is fixed in position by injecting the retaining bag, and the bladder is irrigated. One short Penrose drain is placed over the wall of the rectum, and the wound is closed by approximating the levator ani muscles with one or two chromic catgut sutures, and the subcutaneous tissue and skin with interrupted silk or dermal Stewart sutures.

#### PPLICATION OPERATION FOR IMPOTENCE

Because ribbon gut does not cut through delicate tissues, this material was utilized in the development of an operation for the cure of certain types of impotence. This operation consists in compressing the dorsal veins of the penis by a ribbon gut suture and plicating the bichiocavernosus muscle on each side and the bulbocavernosus muscle. A series of animal experiments were first performed which proved that these muscles are essential to the function of erection; that tightening the bichiocavernosus muscle on each side and the bulbocavernosus, in dogs, produces erections which are under control of the dog's mind. The results in animals were so striking that a series of operations in humans was done. Since the operation was devised 8 years ago, 166 patients have been operated upon at the Brady Foundation; 90 per cent of these have been cured or greatly improved, and only 10 per cent have failed to show improvement. In all cases the operation was performed as a last resort after all other methods of treatment had been tried, including neurological measures and the administration of hormones.

The operation is done as follows: The patient is placed on the operating table in the exaggerated lithotomy position and No. 9 F sound is passed into the urethra. An incision is made over the bulging part of the perineum, extending in the midline from a point about 1 centimeter from the anal margin down toward that structure for about 5 centimeters. A branch is then made laterally on each side to a point just above the attachment of the crus penis, the completed incision resembling an inverted V. The incision is deepened through fat and areolar tissue until the corpus spongiosum, surrounded by the bulboc-

avernosus, and the crus penis (corpus cavernosum) on each side, surrounded by the bichiocavernosus, are exposed.

Chronic ribbon gut, studded with an atraumatic needle, is inserted into the lateral edge of the bulbocavernosus muscle pulled across the belly of the muscle and passed through the other side with just sufficient strain to plicate the muscle and produce the exact amount of pressure to reinforce any contraction necessary to aid in producing an erection. Two more similar stitches may be required to tighten the whole muscle. A figure-of-eight ribbon-gut suture is inserted into the bichiocavernosus muscle on each side, care being taken not to injure or unduly compress the fairly numerous nerves and blood vessels here. By tightening the suture, a reef is taken in the muscle, thus shortening it by about 1 inch. The wound is closed in layers without drainage.

An incision 4 centimeters long is then made over the suspensory ligament, which is exposed and freed by blunt dissection. A compression suture is placed in the two leaves of the suspensory ligament of the penis, causing moderate, persistent compression which prevents a too rapid flow of blood out of the organ.

The success of this operation apparently depends upon the use of chronic ribbon gut, which does not tear through the delicate muscles as does ordinary twisted catgut.

#### PPLICATION OPERATION FOR THE RELIEF OF INCONTINENCE OF URINE AND FECES IN THE MALE

At the Brady Foundation, incontinence of urine in males has been cured by plication of the bulbocavernosus muscle and has been controlled by regular evacuation, in 26 cases in the past 6½ years.

In 1938, the author in collaboration with Major Robert W. Hunt, now in the Medical Department of the Army Air Corps, did a series of animal experiments in which ribbon gut was used to plicate the rectum and urethra of dogs. These demonstrated that the rectum may be constricted excessively with chronic ribbon gut so that the animal must use great force to evacuate ribbon-like feces. Two dogs in the series had perfect fistulas, purposely produced, which healed spontaneously. The results of the method were so satisfactory that a small number of humans suffering from incontinence of urine and feces were operated upon, successfully curing most trying and disabling condition. The principle involved is the production of a narrow ring of relaxed elastic viscous which can be caused to empty by exerting pressure.

Our operation for the cure of incontinence of urine and feces in the male consists of 2 procedures, both of which may be accomplished through one incision in the perineum. An inverted-Y incision is made in the perineum over the bulbocavernosus muscle, the two arms of the Y extending down on each side of the rectum almost to its most dorsal level. The incision is deepened through subcutaneous tissue and Colles' fascia until not only the bulbocavernosus muscle is uncovered but the ventral and lateral walls of the rectum as well. A small sound is passed into the urethra (No. 19 F in adults, a much smaller one in children). Mattress sutures of chromic ribbon gut are inserted low down on each side of the bulbocavernosus muscle, pulled tightly across the posterior surface, and tied in a square knot. Usually 3 such sutures are needed to plicate the entire muscle, but in children 2 may suffice. The object is to produce an elastic narrowing of the bulbous portion of the urethra so that the patient must use considerable force to empty his bladder.

The tissues are then freed from the anterior and lateral walls of the rectum, the dorsal surface being uninterfered with. A suture of chromic ribbon gut is inserted in the rectal wall on one side and a mattress suture is then taken through the muscularis on the opposite side. This suture is tied tightly, plicating the rectum—a hemostat being inserted in the lumen of the rectum during the tying to determine the desired caliber of the lumen. A second similar plication is made just above the first, and a third if the lumen is not sufficiently constricted by these two.

The first patient operated upon in this manner was a boy of 8 years who had had both ureters transplanted into his sigmoid because of exstrophy of the bladder. Thereafter his partial incontinence of feces became more pronounced until it was practically complete. Plication of the rectal musculature was followed by a rectal fistula which healed rapidly under the influence of alpine light applications. He now has perfect control of his fecal and urinary streams. The second patient was a 10 year old boy with fecal and urinary incontinence due to spina bifida. After the operation he had to be catheterized for several days and was then taught to exert pressure on his bladder, using abdominal muscles and even his hands. His bladder gradually expanded until it held 105 cubic centimeters of urine at time of discharge from hospital. Fecal control was immediate and satisfactory. Control over rectum was obtained by the children being trained to empty this organ at regular intervals, using pressure, until finally they had complete control over evacuations.

#### OPERATION FOR URINARY INCONTINENCE IN THE FEMALE

In the female, we have also had success in relieving urinary incontinence in numerous instances by two methods of repair in which chromic ribbon gut is used. A dozen female dogs were first operated upon in order to determine the value of ribbon gut for this purpose. The choice of operation depends on the situation which the surgeon encounters. If the urethra is very large and patulous, and the patient is entirely incontinent, the anterior surface of the urethra is plicated with ribbon gut, the viscus being tightened over a No. 10 F baby catheter, which is left in position for 2 or 3 days. If, on the other hand, the patient merely loses a few drops of urine on coughing or other muscular exertion, encircling the urethra with a piece of ribbon gut and tying it snugly will be all that is necessary to effect a cure. Fibrous tissue replaces the ribbon gut, as shown in the animal experiments.

To date 27 females have been operated upon at the Brady Foundation by these methods. The operative results have been favorable in all but a few cases in which reoperation was necessary.

#### REPAIR OF HERNIAS WITH RIBBON GUT

In the past 8 years we have used chromic ribbon gut for the repair of hernias which we have encountered in various urological lesions.

The technique employed is as follows. An incision is made from the spine of the pubis upward and outward over the inguinal canal, and deepened through the subcutaneous tissue and conjoined tendon into the inguinal canal. The hernial sac is isolated and opened. A transfixion suture of chromic gut is tied at the neck of the sac, the excess being excised. The tied-off sac is allowed to retract inside the internal inguinal ring. Three or four ribbon-gut sutures are placed under the cord in the transversalis muscle and fixed at the lower border of the shelving edge of Poupart's ligament, the lowest suture being affixed to Gimbernat's ligament at the anterior spine of the pubis. The fascia is then sutured to cover the canal and its contained cord in the usual manner. The wound is closed in layers, silk sutures being used for the skin closure.

In all, we have operated upon 104 inguinal hernias and 6 abdominal hernias by the ribbon-gut method. There have been 2 known recurrences in this series. In one, the patient had been operated upon three previous times, with recurrence in each instance, and the tissues were so scarred and thin that success was precluded by the nature of the field. In the other failure, a

tremendous hernia was present the patient had worn a truss for 20 years, and this had thinned out the tissues to nothingness.

On the other hand we have used ribbon gut in 6 cases of recurrent inguinal hernia with success.

We consider ribbon gut to be superior to any other type of repair material for herniorrhaphy in that it is broader stronger substance than is ordinarily used and the resulting repair scar has proved to be more firm and solid than that which results from the use of catgut or kangaroo tendon. Then, too, silk sutures, as well as chromic catgut which has been largely used for this operation frequently cut or pull through the tissues, with the resulting recurrence of the hernia.

#### OTHER USES OF RIBBON GUT IN SURGERY

Attention is called to the fact that many surgeons in all parts of the world are using ribbon gut successfully not only in urological surgery but for the relief of many other surgical lesions.

Mr. Terrence Millin has reported a series of successful operations upon impotents, using the method herein described.

Dr. Daniel Chanb, Jr. of Panama, has reported a new method of suspending the uterus with this material (when the uterus is free and movable and the adnexa intact). In brief, this procedure is as follows: The uterus having been delivered at the abdominal wound, the uterosacral ligaments are singly brought together over the posterior aspect of the uterocervical segment by 2 or 3 sutures of chromic ribbon gut studded at one end with an traumatic needle. With a sharp knife tunnel is made on the posterior aspect of the fundus uteri. The round ligaments having been drawn through the broad ligaments, one is transfixed by the ribbon gut which is carried through the tunnel to the opposite round ligament and tied. An extra suture of ribbon gut is placed so as to transfix the round ligaments and the peritoneal covering of the uterus overlying the tunnel.

The repair of rupture of the liver and spleen has been successfully accomplished with this material.

The ligation of a bronchus in lobectomy (pulmonary) has been a useful adjunct to lung surgery.

#### SUMMARY AND CONCLUSIONS

Ribbon gut for a number of reasons, has been a great boon to the surgeon. It is an animal membrane, very soft and pliable, which permits the development of fibroblasts between its own fibrilla. There is nothing done to this untwisted catgut to prevent this ingrowth of fibroblasts from surrounding structures. It may be made ready for use in the operating room in unlimited

amounts at a moment's notice. It is fitted with an traumatic needle.

In the use of human fascia lata a second operation is necessary this is time consuming and adds the hazard of another wound.

We have seen no advantage in the use of preserved ox fascia lata, and a number of disadvantages as compared with ribbon gut. The longest ox fascia strips obtainable are only about 12 inches, while ribbon gut is 18 inches in length. In addition to the objection that preserved ox fascia is dead tissue and so will readily slough out is the disadvantage that ox fascia lats cannot be sterilized by heat without destroying its physical integrity. Hence, resort must be had to chemical sterilization, which is dangerous because of its unreliability. On the other hand, ribbon gut possesses the high safety factor of heat sterilization. Moreover ox fascia lata does not tie very well and a knot made with this material might slip; therefore, it would not be safe for some of the operations on the kidney in which ribbon gut has proved so successful.

Ten years of experience with the use of ribbon gut in renal and prostatic surgery, herniorrhaphy and plastic operations for the cure of impotence, incontinence of urine, and incontinence of feces, and reports of the efficacy of this material in suspension of the uterus and other operations have convinced us that ribbon gut is a most important addition to the surgeon's armamentarium. In the various types of operations coming under our personal observation, no material thus far encountered has supplanted or even equalled it.

#### REFERENCES

- CHANDLER, D. VEE, JR. *Surg Gyn Obst.*, 91 73 8-6.
- HARRIS, C. A. *Am J Surg.*, 91 4 300.
- LOWMEYER, O. S. *South M J.*, 931, 27 30.
- Idem. *J Kansas M Soc.*, 935, 26 307.
- Idem. *J Missouri M Ass.*, 935 12 33.
- Idem. *South M J.*, 935, 28 29.
- Idem. *N York State J M.*, 934, 26 50.
- Idem. *J Urol Balt.*, 935, 30 400.
- Idem. 940, 43 75.
- LOWMEYER, O. S. and BLANCK, C. C. *Surg Gyn Obst.*, 913, 57 494.
- LOWMEYER, O. S. and LOVETT, FR. *J Urol Balt.*, 941, 43 45.
- LOWMEYER, O. S. and HART, R. W. *J Urol Balt.*, 939, 4 3.
- LOWMEYER, O. S. and KILBOUR, R. N. *J Urol Balt.*, 941, 43 6.
- LOWMEYER, O. S. and KILBOUR, R. N. *Clinical Urology*, Vol II, pp 574-578 Baltimore: The Williams & Wilkins Co. 940.
- LOWMEYER, O. S. and MEYER, J. H. *J Urol Balt.*, 941, 43 55.
- T. DICK, F. P. *J Urol Balt.*, 940, 43 506.
- VERICK, W. P. J. and FORTY, W. E. *J Urol Balt.*, 941 46 390.

# THE PATTERN OF UTERINE MOTILITY THROUGHOUT LABOR WITH SPECIAL REFERENCE TO INERTIA

A Study of 105 Patients with the Loránd Tocograph  
DOUGLAS P MURPHY, M.D., F.A.C.S., Philadelphia, Pennsylvania

**T**HIS is the second report dealing with uterine motility during labor. The first one concerned the magnitude of the contractions and the effects of advancing labor, parity and dystocia upon it (3).

The present communication considers the pattern of contractions exhibited by patients having normal labors and by those experiencing primary inertia. Both publications are based upon observations on the same group of women.

## MATERIALS AND METHODS

Uterine activity was registered with a Loránd tocograph (1, 4). This is a simply constructed, small mechanical device which records certain characteristics of the uterine contractions through the medium of the abdominal wall.

Observations were supplied by 105 patients delivered in the Hospital of the University of Pennsylvania during 1942 (3). The uterine activity of these women was registered at 1½ to 2 hour intervals from the time they were admitted to the hospital in labor until they were delivered. Tracings of the uterine motility of patients experiencing normal and inert labors appear in Figures 1 to 4. Each figure comprises all of the observations upon a patient. The earliest record appears at the top of each series. All four figures are reproduced on the same scale. The onset of labor was based upon the time that the first pains appeared. In the columns marked "o," were "before delivery" the lowermost tracings marked "o," were started within 1 hour of delivery.

The base lines at the ends of each tracing represent the level of the writing point of the tocograph before the instrument was placed upon the patient's abdomen. The tone of the uterus is measured in terms of the elevation of the graph above this base line.

Vertical strokes upon the sides of waves or between them resulted from fetal movement. Vertical lines at the crests of waves, at the end of labor, resulted from bearing down movements.

From The Gynecean Institute of Gynecologic Research Department of Obstetrics and Gynecology University of Pennsylvania

produced by voluntary contractions of the abdominal muscles

## RESULTS

*Pattern of normal labor* Figures 1 and 2 reproduce the contraction patterns of 2 patients who had normal labors. The tracings shown in Figure 1 were secured from a primipara who experienced a 12 hour labor terminating in a spontaneous delivery. Figure 2 illustrates the pattern of a secundipara who had a 16 hour labor also ending in a spontaneous delivery.

The contraction patterns of these two individuals have certain characteristics in common and exhibit certain significant differences. In addition, the patterns of these two patients differ significantly from those of women who experienced primary inertia (Figs 3 and 4).

The characteristics of the patterns common to the two patients are as follows: (a) The regular recurrence of the contraction waves, and the initiation of this attribute early in labor, (b) the magnitude of the waves, (c) the close resemblance between any one wave and its following trough, with adjacent waves and their respective troughs.

In spite of the number of characteristics of the graphs common to both patients, their contraction patterns differ from each other in a general way.

*Pattern of primary inertia* Figures 3 and 4 illustrate the contraction patterns of two individuals who experienced a poor quality of uterine motility from the onset of labor. The tracings in Figure 3 were supplied by a primipara who had a 47 hour labor ending in a breech delivery. Figure 4 reveals the contraction pattern of a primipara who went through a 31 hour labor ending in a mid-forceps delivery.

The patterns of these two individuals have certain characteristics in common and likewise exhibit certain significant differences. Furthermore they differ significantly from the patterns of the patients who had normal labors (Figs 1 and 2).

The characteristics of the patterns which are common to these two patients are as follows: (a) Contraction waves of average small magnitude, (b) arrhythmicity of occurrence of successive con-

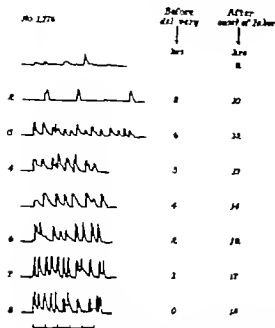


Fig. 1. Tocographic record of normal 8 hour labor in primipara. Tracing cervix dilated 4 centimeters. Tracing 7 cervix dilated completely. Time intervals 3 minutes. Note, ( ) rhythmicity of waves, (b) magnitude of waves which increases progressively, (c) similarity in size and shape of successive waves. Compare with same characteristics in tracings of primary inertia, Figures 3 and 4.

tractions, (c) waves which fail to resemble each other very closely in shape and magnitude. The outstanding difference between the patterns of these two patients is the disparity in the degrees of their uterine tone. Figure 3 shows a low uterine tone (hypotonic inertia) with the wave troughs on the level of the base lines. Figure 4 reveals a high uterine tone (hypertonic inertia).

The patterns of the patients experiencing primary inertia differed significantly from the patterns of the patients having normal labor in respect to items, a, b and c.

#### EVALUATION OF STUDY

To distinguish more readily the difference in the contraction patterns associated with normal and inert labors, the tocographic criteria of a normal labor might be restated in the following terms. Normal labor is characterized by a pattern in which, in one's mind's eye, it is possible to superimpose any one contraction wave and its following trough, upon either of its adjacent waves and their respective troughs. The more

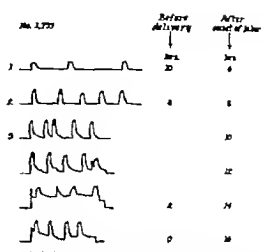


Fig. 2. Tocographic record of normal 16 hour labor in multipara. Tracing cervix dilated centimeters. Tracing 6 cervix dilated completely. Time intervals 3 minutes. Note (a) rhythmicity of waves, (b) magnitude of waves, (c) similarity in size and shape of successive waves. Compare with same characteristics in tracings of primary inertia, Figures 3 and 4.

nearly this ideal can be approached the better is the quality of the uterine motility. Early in labor this rule holds true even though the magnitude of the waves may be small, although the earlier that large waves are established the more rapid will be the progress of labor. Good uterine motility during labor can be predicted, even before the onset of labor. If a pattern of contraction measuring up to the above criteria is established at that time.

Published observations made with the tocograph upon many patients not included in this report, show that each individual possesses a distinct contraction pattern during pregnancy which in a modified form is carried over into labor.

The accompanying illustrations indicate the extent to which the pattern of contractions present early in labor is maintained throughout the remainder of labor. This persistence of the pattern makes it possible for us to secure, early in the labor, fairly good idea of what the rest of the labor will be like. And for this purpose ordinarily it is necessary to secure only two tracings, taken about an hour apart.

Such observations make it possible for us to detect the existence of uterine contractions of poor quality relatively early. With this knowledge we are placed in a position to treat primary inertia earlier and therefore better.

According to Lórénd, primary inertia is characterized primarily by the feebleness of the uterine

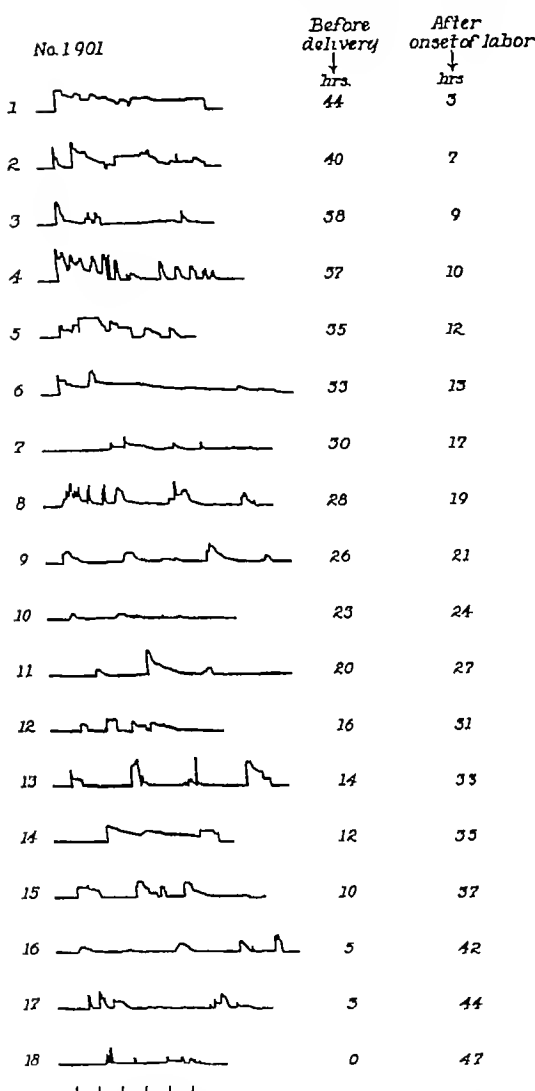


Fig 3 Tocographic record of a 47 hour labor complicated by hypotonic primary inertia, in a primipara. Tracing 1 cervix dilated 6 centimeters Tracing 7 cervix dilated completely Time intervals 3 minutes Note (a) absence of good rhythmicity of waves, (b) small size of waves, (c) dissimilarity in size and shape of successive waves, (d) no elevation of waves above base line Compare wave characteristics with those in tracings of normal labor, Figures 1 and 2

ine contractions To this we would add the arrhythmicity of occurrence of the contractions and their failure to resemble each other

A consideration of primary inertia from the standpoint of its tocographic detection should not be passed over without drawing attention to

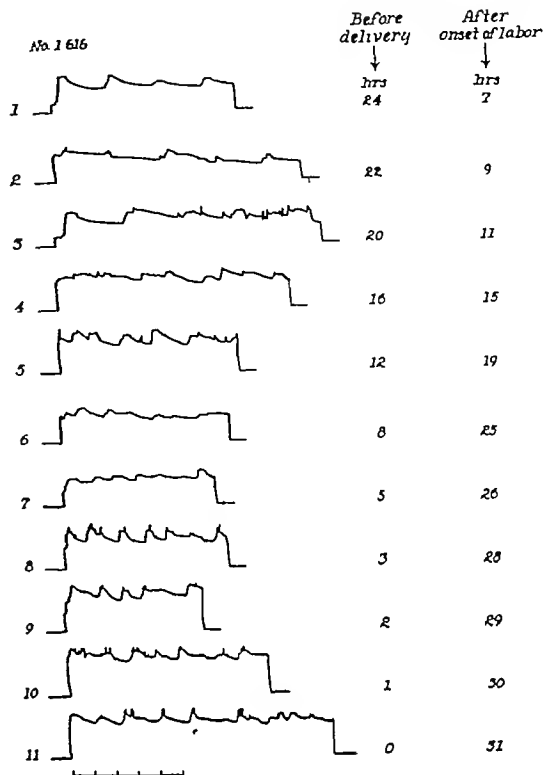


Fig 4 Tocographic record of a labor of 31 hours complicated by hypertonic primary inertia in a primipara. Tracing 1 cervix dilated 6 centimeters Tracing 7 cervix dilated completely Time intervals 3 minutes Note (a) absence of good rhythmicity of waves, (b) small size of waves, (c) dissimilarity in size and shape of succeeding waves, (d) high uterine tone, indicated by elevation of main part of each tracing above base line at ends of tracing Compare wave characteristics with those of tracings of normal labor, Figures 1 and 2

Lóránd's important contribution to this subject Lóránd recognizes three degrees or types of primary inertia (1) normotonic, (2) hypotonic, (3) hypertonic (Fig 5) In each instance the uterine contractions are feeble but also in each case the tonus of the uterus is different

The treatment of primary inertia continues to be a matter of discussion among obstetricians, and this applies especially to the use of oxytocic drugs Some physicians use such drugs and others do not Lóránd considers that the decision to employ an oxytocic substance in the treatment of primary inertia should depend upon the type of inertia which is present. If the uterine tone is normal or low, oxytocic drugs in very small dosage—1 minim or less—can be employed safely, but if the uterus is hypertonic the use of any oxytocic drug is



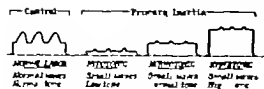


Fig. 1. Lóránd's classification of primary inertia. His graphic representation of toconographic picture of (1) normal labor, (2) hypotonic, normotonic and hypertonic primary inertia. Note: (a) small size of waves in all types of primary inertia, (b) different degrees of uterine tone associated with the small waves of primary inertia.

contraindicated. In such cases it is far safer to rupture the membranes if this has not occurred already. The employment of an oxytocic drug when the uterus is hypertonic is very likely to increase further the tetanic state and thus may lead to serious consequences. In view of our knowledge of the uterine motility which occurs during labor gained from toconographic recordings, we are fully in accord with Lóránd's statements regarding the use of oxytocic drugs. We might add that the successful treatment of primary inertia is greatly aided by the securing of repeated toconographic records of the uterine activity. They assist in determining the type of the inertia and in recording both the character and degree of the uterine reaction to any oxytocic drugs which may be employed. Under toconographic control it becomes safe to use small doses of oxytocic drugs in the treatment of primary inertia.

#### SUMMARY AND CONCLUSIONS

1. The uterine contractions of 105 women in labor were recorded graphically with a Lóránd toconograph. Observations were made at 1½ to 2 hour intervals throughout the greater part of labor.

2. Each individual experienced a contraction pattern which was peculiar to herself.

3. Normal labor was characterized by: (a) contractions of appropriate magnitude, (b) a relatively high degree of rhythmicity of occurrence of successive contractions, (c) contractions which resembled each other fairly closely in magnitude and in general character.

4. Primary inertia was characterized by: (a) contractions of small magnitude, (b) considerable arrhythmicity of occurrence of successive contractions, (c) contractions which failed to resemble each other in magnitude and general character.

5. The classification of inertias into normotonic, hypotonic, and hypertonic as described by Lóránd is outlined and confirmed.

6. From our observations we conclude that the Lóránd toconograph is a useful instrument for detecting the presence of primary inertia, and distinguishing the type.

#### REFERENCES

- Lóránd, S. *Monatsh. Geburtsh. Gyn.* 95: 703, 1917.
- Idem. *Zbl. Gyn.* 1917, 6: 235-291.
- Murray D. P. *Surg. Gyn. Obst.* 1913, 75: 40-43.
- Idem. *Surg. Gyn. Obst.* 94: 73, 63-635.

# EDITORIALS

---

## SURGERY Gynecology and Obstetrics

FRANKLIN H. MARTIN  
Founder and Managing Editor  
1905-1935

---

LOYAL DAVIS, EDITOR

*Associates*

SUMNER L. KOCH                      MICHAEL L. MASON

DONALD C. BALFOUR, *Associate, Editorial Staff*

---

JULY, 1943

---

### MASSIVE GASTRIC HEMORRHAGE

**A**CUTE, chronic, chronic perforating, and bleeding peptic ulcers are more prevalent today than at any previous time. Under the stress of war the tempo of the layman, the industrial worker, and the men in the services has been stepped up beyond all past experience. In many communities the normal population of peace times has been increased one hundred per cent or more, and the daily life of all these individuals is characterized by stress, strain, and anxiety. With the increasing prevalence of acute peptic ulcers, and particularly the reactivation of chronic ulcers, hemorrhage from stomach and duodenal ulcers is becoming a more frequent problem for the internist and the surgeon, so it seems fitting that it should be reconsidered and emphasized at this time.

The place of surgery in gastric hemorrhage is definitely debatable. Whether surgery should or should not be done in a given case is yet unsettled by any criteria which may be

laid down for routine following. Mortality statistics of massive gastric hemorrhage (with or without operation) are not widely confirmed by the medical profession, nor based on facts that are sufficiently substantial for acceptance at this time. Prior to fifteen years ago, almost everyone followed the conservative methods of treatment for gastric hemorrhage, and the confusion today is due to propaganda set forth by Finsterer and Meulengracht which, when compared, is diametrically opposed.

About 1927, Finsterer reported a large series of cases in which he advocated immediate surgery and stated that operation of a radical nature—meaning resection—if done within forty-eight hours, resulted in a mortality rate of only 5 per cent, whereas operation delayed for seven days or more resulted in a mortality rate of 33⅓ per cent.

In 1935, Meulengracht<sup>1</sup> reported a series of 251 cases with a mortality rate of 1 per cent in which the treatment consisted of immediate feedings of food, even gross food, such as meats, potatoes, stewed fruits, cheese, and fresh bread. He compared this with a series of control cases which had been treated conservatively by the Sippy type diet, in which the mortality rate was 7.9 per cent. It must be remembered in considering this subject, that the patient with the average mild or repeated mild gastric hemorrhage may not require operation, while patients with severe symptoms do demand hospitalization and probably surgery. It must also be remembered that, in the case of surgeons in general, the mortality rate following operations in severe cases will undoubtedly be 10 per cent or more. The old accepted teaching has been

<sup>1</sup>Lancet 1935, 2: 1-20

that with one hemorrhage conservative treatment should be advocated, with two hemorrhages operative interference must be considered and with three hemorrhages operation should always be done. This is probably true as to the third hemorrhage in a given case but the rule cannot be applied generally.

An example of this contention can be illustrated by the following case of a patient recently seen—a man, forty years old, who had had ulcer symptoms over a period of years though the pain had never been severe. He had never consulted a physician. Without warning he had a massive hemorrhage. It is reasonable to argue that this type of case does not demand immediate operation for three reasons: (1) The patient had never had any intelligent medical care. (2) we know that this type of ulcer is technically difficult to deal with by operation in an emergency and (3) the patient may never bleed again. On the other hand a patient who has had severe pain which has proved intractable to medical care and is associated with massive hemorrhage should be subjected to surgical intervention without delay. Such symptoms usually mean a chronic ulcer on posterior wall penetrating into pancreas and therefore, most unlikely to undergo spontaneous arrest of hemorrhage.

It is thus seen that two types of hemorrhage demand surgery: (1) that in which massive hemorrhage has recurred; (2) that in which a massive hemorrhage is associated with a chronic ulcer penetrating into the pancreas.

In operative procedures in these cases, due consideration should also be given to the question as to just how much protection surgery will afford against future hemorrhage. It is my opinion that protection afforded against future hemorrhage by surgery is directly proportionate to the amount of radical surgery done. Conservative operations—plasties, simple excision or gastroenterostomy—afford pro-

tection in 50 per cent whereas radical resection affords protection in 85 per cent of cases.

The surgeon should further be familiar with the probability of spontaneous arrest of hemorrhage in ulcer cases. Statistics now well establish the fact that in hemorrhage cases patients under fifty years of age are usually afforded spontaneous arrest of bleeding and protection in all but 45 per cent, and all patients over fifty with massive hemorrhage show spontaneous arrest in only 33 per cent of cases.

It would be interesting to discuss the instance of bleeding in a large series of cases in other conditions such as esophageal varix, chronic gastritis and pedunculated tumors, particularly the leiomyosarcomas. Such statistics show that the instance of bleeding in duodenal and gastric ulcer is approximately 10 per cent, in gastric cancer 8 per cent, in gastrojejunal ulcer 20 per cent, in esophageal varix 17 per cent, in solid tumor of the stomach 75 per cent, and in chronic gastritis 9 per cent.

The advantages of the Levin tube in the immediate treatment of gastric hemorrhage should be emphasized. Its use is advisable for four reasons: (1) It eliminates gastric secretions and saliva which materially interfere with the formation of a strong occlusive thrombus. (2) It keeps the stomach empty and contracted which as in urinary bladder is the most favorable state for thrombus formation. (3) it indicates to us any episodes of fresh bleeding early before there is a marked fall in blood pressure or development of nausea. (4) It eliminates vomiting which as we all know contributes to additional hemorrhage by the dislodgment of occlusive clots. Finally in a given case of massive hemorrhage it is impossible to tell whether the patient will live or die. The mortality rate of conservative is lower than that of operative treatment, so it would seem best to adopt medical management first.

ROBERT L. PAVAT.

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

THE second revision by Dr Christian of Osler's universally standard textbook<sup>1</sup> of medicine is the 14th edition of this famous reference work, revised and published in 1942. This edition marks the 50th anniversary of the original Osler edition of 1892. Intervening revisions from Osler's 9th to Christian's 13th were edited by Dr Thomas McCrac, previously assisting Osler.

As noted by Christian, Osler's *Medicine* has always epitomized the practice of medicine as modified by the guiding hand of an editor who gathered and interpreted medical wisdom in the light of personal hospital, office, and teaching experience over a long period of years. Thus the text remains the portraiture of disease largely as seen by three authors against the background of periodic advances in medical knowledge made by men the world over. Thus a continuity in thought and a balance in description has obtained, obviating the fault inherent in books of multiple authorship.

The organization remains the same as that originally designed by Osler, with minor alterations. No new major sections have been added, nor important deletions or changes in order of subject matter. Yet, a comparison of this edition with the 8th, the next to the last edited by Osler published in 1919, reveals a 25 per cent increase in size. This is indicative of the thoroughness with which successive editions have been revised. Study of the organization of sections further shows that time and change in knowledge have not been permitted to introduce any hint of obsolescence. Careful manipulation by its editors has reclassified diseases as their nature and case have been more clearly revealed, obsolete terms have been weeded out, simplification of knowledge has been recognized by simplification of classification.

Adequate description of detail would be impossible because of size. A few examples will illustrate the insight with which revision has kept this old text up to date. The use of sulfadiazine in the treatment of bacterial pneumonia is included in detail. Yet an accurate description of virus pneumonia points out that sulfonamides appear to be of no benefit. The section on diabetes mellitus contains a concise review of modern physiological advances and their possible significance in terms of etiology. Treatment with protamine zinc insulin is described in detail and the practically important fact is pointed out that it

must not be mixed with ordinary insulin but injected separately. The excellent section on diseases of the nervous system has been retained and amplified.

This dignified reference work in all phases of internal medicine, written and edited by scholarly practitioners with wisdom and experience in a uniformly simple, complete and concise style, may well rank as the leading authority in internal medicine in the world today. Every student and internist should know it well.

ARTHUR R. COLWELL

THE 7th edition of *Diseases of Women*,<sup>2</sup> a textbook that has been used for many years in England, has recently been published. The list of authors assures one that the opinions are well founded and well tried. It is highly praiseworthy that, in the midst of war and with many of the authors in active military service, they still found time to bring their textbook down to date and give modern teaching to students.

This is a small book of 435 pages, but it covers the whole field of gynecology and also includes a concise section on disorders of micturition. My chief criticism is based on the obvious limitations imposed by the lack of space, which prevents adequate treatment of some of the subjects. Hence, there is no bibliography whatever in the book, and no reference to the historical features or sources of our knowledge. Because of lack of space, some subjects are compressed almost into outline form. Menstruation includes only 2 pages, vaginal discharges are considered in 4 pages, and pruritus is likewise hardly more than mentioned. These are common complaints and their treatment is of greater practical interest to the average doctor or student than the details of surgical anatomy and embryology.

Perhaps the lack of space is responsible for the rather matter-of-fact manner in which endocrine therapy is dismissed. In some parts, it is well presented, in others, it is dismissed by didactic statement. In general, we are not as sure of ourselves in endocrine therapy as these authors seem to be, especially in the treatment of such things as functional bleeding.

On the other hand, some subjects are treated very completely—the chapters on tubal pregnancy, fibromyoma, infections, and other major subjects being good. The method of discussing adolescence, the menopause, and amenorrhea is very clear and sensi-

<sup>1</sup>*DISEASES OF WOMEN*. By Ten Teachers under the direction of Clifford White, M.D., B.S. (Lond.) F.R.C.P. (Lond.) F.R.C.S. (Eng.) F.R.C.O.G. Edited by Sir Comyns Berkeley Clifford White and Frank Cook. 7th ed. Baltimore: The Williams & Wilkins Co. 1942.

<sup>2</sup>*THE PRINCIPLES AND PRACTICE OF MEDICINE*. Originally written by Sir William Osler, Bart. M.D. F.R.C.P. F.R.S. Designed for the use of Practitioners and Students of Medicine. By Henry A. Christian, A.M. M.D. LL.D., Hon. Sc.D. Hon. F.R.C.P. (Can.) F.A.C.P. 14th ed. (semicentennial 1892-1942). New York and London: D. Appleton Century Company Inc. 1942.

ble. The chapter on urinary diseases is short and timely.

In general, this book might be very useful for the student who must get a superficial knowledge of the subject but who does not expect to practice gynecology. It seems too superficial for the practicing physician, surgeon, or teacher.

Nevertheless, as a compendium or condensed collection of the views of these eminent authors the book is valuable to us all as an expression of sound experience. It is a safe basis for guiding students and physicians to further study. In view of the experience through which England has been passing in the past year or two, we can only commend the scientific zeal which urged the completion of this revision and the maintenance of up-to-date and efficient teaching in British medical schools.

LAWRENCE R. W. ARNOLD

A WELL conceived, carefully outlined, concise and lucid presentation of very important and timely subject is made by an authority in Shock by Virgil H. Moon. It is a very practical book. It not only deals with the essential physiological and pathological features and theories of shock, but it also provides chapters on the diagnosis, prevention, and treatment of shock. The subject matter is so concisely presented and well indexed and outlined, that the busy physician will have time to read and refer to those subjects concerning which he needs ready information. The book is highly recommended to every one whose practice presents conditions in which shock may occur.

A. C. IV

WRITTEN by medical authority on legal medicine *The Pathology of Trauma* is designed to cover the pathological anatomy and pathological histology of traumatic lesions. It does not delve into the clinical aspects of this subject.

The book is concise, clearly written, and stripped of excess words. It is so arranged that each chapter deals with the effect of various forms of trauma on one particular organ or system. Especially to be commended are the portions dealing with intracranial hemorrhage as well as the effect of trauma on the heart and kidney. The illustrations are not numerous but all chosen and reproduced. There is an excellent bibliography at the end of each chapter.

This book should be of value to coroners, medical examiners, students, and teachers of pathology. It does not aim to give much assistance toward solving questions of diagnosis or treatment.

G. R. DOCKERTY

THE little book of 54 pages entitled *Gynecologic Surgery* by Goldberger makes no attempt to be a textbook and contains no clinical discussion

of the field of gynecologic surgery. Conditions requiring operative therapy in the field of gynecology are named and the procedures used for their correction are given. The indications for operation and the various steps of the procedures commonly used are named. These are given in outline form without discussion except, occasionally, such statements as "rarely used." All of the methods of surgical therapy are included, the steps being set forth briefly and clearly. The book will be useful for students or for men who after some years in general work are trying to acquire a familiarity with gynecologic surgery. A number of blank pages are provided for the making of notes. A statement on the cover indicates that the book is one of a series of short outlines being published by the same firm.

W. C. DAVENPORT

THE author of *Cancer of the Uterus* is the first director of the Marie Curie Hospital, London. The book is small, one of 50 pages and deals especially with the management of cancer of the cervix and the corpus of the uterus. Short chapters are devoted to the consideration of the pathology of uterine cancer and its lymphatic extension. The author stresses the importance of early diagnosis as the most efficient means of lowering the cancer death rate. She expresses an optimistic opinion. She says that, were all cases seen in their early stages, 60 to 70 per cent of cervical cancers and 80 to 90 per cent of corpus cancers might be cured. With sufficiently early diagnosis this would probably be true. Treatment is dealt with in detail. The descriptions are clear and when illustrations are needed they are supplied. The diagrams indicating the extent to which the effect of radiation may be expected to go are instructive. The dosage, both of radium and x-ray at the Curie Clinic seem a little large to workers in some of the clinics in this country but she explains that treatment is extended over some time.

Technique is fully described, the methods of intracavitary irradiation being indicated, with some discussion of methods employed in clinics other than her own. A large series of patients can be irradiated for malignant disease without some untoward sequelae. Complications and injuries are frankly discussed.

Cancer of the cervical stump is dealt with in a separate chapter. The author states that a more extended use of total hysterectomy could decrease the number of cancers of the retained stump and quite properly states that the wider employment of the more extended operation should depend upon whether its increased mortality over that of the subtotal operation is greater than the incidence of cancer in the stump. The rather extensive study published in 1934 by B. Honey of Philadelphia on this subject is not mentioned.

In addition to the discussion of cancer the author includes a chapter on cancer of the vagina and vulva.

CANCER OF THE UTERUS, by Elizabeth Haddon, C.B.E., M.D. London: Oxford University Press, 1945.

SHOCK, Its Pathology, Prevention, and Management, by Virgil H. Moon, A.M., M.D. Philadelphia: Lea & Febiger, 1944.

THE PATHOLOGY OF TRAUMA, by Allen Richards Martin, M.D. Philadelphia: Lea & Febiger, 1944.

GYNECOLOGIC SURGERY, by Morris A. Goldberger, M.D., F.A.C.S. London, New York, and Toronto: Oxford University Press, 1945.

The views expressed here are those which are well accepted although in most American clinics irradiation is not believed to have great value. The last chapter discusses nonmalignant bleeding. This is well presented although not all gynecologists would feel that they should wait until the hemoglobin is as low as 20 per cent before interfering. We agree that radium should be withheld from the younger patients unless strongly indicated but curettage might well be used before extreme anemia develops.

The book presents an excellent study of the work of the Curie Clinic together with a concise and very sane discussion of the subject of uterine cancer. Workers in other clinics will find it useful.

W. C. DANFORTH

It is refreshing and delightful to encounter "amidst the tyranny of medical literature" such a fine book as *The Hemorrhagic Diseases and the Physiology of Hemostasis*<sup>1</sup> by Armand J. Quick, one might justly state that this work is a "classic."

The history of the development of our knowledge of the hemorrhagic diseases and of the physiology of hemostasis has been presented in a well ordered, clear, and concise manner. In spite of the many important contributions to the subject by the author, one is particularly impressed with his modest and painstaking scientific presentation.

Proper credit is given to each investigator and a very comprehensive bibliography is appended to each chapter. The first portion of the book deals with the physiology of hemostasis, and the latter portion is devoted to a correlation of the results of these studies with the clinical manifestations and therapeutic management of the hemorrhagic diseases.

The format is excellent, the type is large and printed on good paper. There are many excellent tables and charts.

The reviewer heartily recommends this book to all investigators, students, and practitioners of medicine.

GEORGE H. COLEMAN

FULFILLING the need "for a manual to present to the medical and dental professions a concise text that would deal with the early first aid treatment of face and jaw injuries, at the site of injury," the small book, *Synopsis of Traumatic Injuries of the Face and Jaws*, by Douglas B. Parker, entitles the author to feel that he has accomplished his purpose.

Disclaiming the intent of offering a textbook on the subject of oral or plastic surgery, the author has drawn upon his own years of experience and that of many others well known and respected in this field in such an admirable way that the book could well be used as a text. Especially is this true in the training of dentists to greater familiarity with the

problems of care and treatment of maxillofacial injuries.

The general surgeon who reads this book will realize how valuable will be the assistance of a dentist trained according to the precepts set forth in it, and will himself be more aware of this branch of surgery. There are no unproved theories, no extraneous material, nothing but sound information and teaching, concisely presented.

Of particular value are the chapters on first aid, shock, burns of the face, and the newer methods of treating jaw fractures. Surgical reconstruction and surgical prosthesis are subjects of wide interest and the chapters devoted to their consideration are well done. The book is an achievement, and it is amazing that so much of real value is found in this pocket sized book of 326 pages.

FREDERICK W. MERRIFIELD

A CRITICAL selection of the worth while articles of the year on orthopedic and traumatic surgery is presented in *The 1942 Year Book of Industrial and Orthopedic Surgery*<sup>2</sup> by an editor exceptionally qualified for the task. The whole value of such a work depends on the experience and wisdom of its editor for he must cull the essence from the literature and assemble it in a series of reviews interpolated with occasional editorial notations. As a matter of general policy, only reviews of proved therapeutic value appear.

Particularly noteworthy is a series on fractures and their treatment. Those articles foreshadow marked changes in the older standard methods of treatment, with a marked shift toward various methods of internal fixation and they begin to show the influence of war surgery. There are several articles on the confusing, painful affections of the shoulder, and in the same section are found both medical and surgical care of the related scalenus anticus syndrome. One finds very little about the Kenny treatment of infantile paralysis but, on the other hand, revolutionary changes in the care of acute osteomyelitis. The editor believes that the subject matter of orthopedic and traumatic surgery should be grouped and this selection of reviews would certainly be of interest to both.

At the end of the volume about 50 pages are devoted, entirely, to the problems of industrial medicine. The handy size, good illustrations, over 300 in this one, and generally excellent format of the year book is too well known to require comment.

ROBERT C. LONGFORD

A VOLUME of about 900 pages, *Textbook of Gynecological Surgery*<sup>3</sup>, deals entirely with the technique of pelvic surgery. Diagnosis and path

<sup>1</sup>THE HEMORRHAGIC DISEASES AND THE PHYSIOLOGY OF HEMOSTASIS. By Armand J. Quick, M.D. Springfield, Ill. and Baltimore, Md. Charles C. Thomas, 1941.

<sup>2</sup>SYNOPSIS OF TRAUMATIC INJURIES OF THE FACE AND JAW. By Douglas B. Parker, M.D., D.D.S. St. Louis, Mo. The C.V. Mosby Co., 1941.

<sup>3</sup>THE 1942 YEAR BOOK OF INDUSTRIAL AND ORTHOPEDIC SURGERY. Edited by Charles F. Painter, M.D. Chicago. The Year Book Publishers, Inc., 1942.

<sup>4</sup>A TEXTBOOK OF GYNECOLOGICAL SURGERY. By S. Comyns Peckley, M.A., M.C. Canab., F.R.C.S. (Lond.), F.R.C.S. (Ed.), M.B.S.A. (Hons.), F.R.C.O.G. and A. J. Forster, M.S., M.D., B.S., Lond., F.R.C.S. (Lond.), F.R.A.C.S., M.R.C.P. (Lond.). Published by J. & A. Churchill, London, New York, Toronto and Melbourne. Cassell & Co., 1942.

ology are not touched upon. Some of the chapters have been rewritten and such new material has been added as the advances in gynecological surgery have demanded. Forty-four new illustrations have been added. The illustrations, for the most part, are line drawings and indicate well the steps in the performance of various procedures although they lack something of the artistic appearance characteristic of wash drawings. A number of excellent colored plates are included. The authors are both men of great experience and of reputation not bounded by the limits of their own country. The book gives an excellent idea of operative gynecology as practiced by the best of our British confrères. Although, as the authors state their intent is to describe operative procedures in such a manner that those of lesser experience may understand them, the book is well worth the attention of all who are interested in the field of gynecology.

The name of one of the authors has long been associated with the extended operation for cancer of the cervix. The chapter on this subject is of particular interest. The technique is clearly described and the facts as to choice of cases and results are given with entire frankness.

A chapter is devoted to intestinal operative procedures. The pelvic surgeon should by all means be able to attend to operative injuries of the bowel, but the inclusion of a description of excision of the rectum seems somewhat beyond the bounds of gynecology.

The chapter on postoperative care is a useful one and one may commend it although in most clinics in this country infection is not given by cutting down upon the vena and inserting a cannula but by the simple use of needle. Postoperative complications are adequately discussed.

A note of conservatism seems to pervade the book and this does not lessen its value particularly to the younger surgeon. The book deserves commendation and should be among those to which one may refer who seeks information concerning the surgical part of the specialty of gynecology. The epilogue which has been added to this edition, is commended to those whose reputations are in the making. This revision should considerably extend the already long and useful life which this work has enjoyed.

W. C. DANFORTH.

**I**n a small, convenient-sized pocket manual of 96 pages Raven's *The Treatment of Shock*, summarizes briefly the present day conception of some of the variables which constitute the shock syndrome and the advances in treatment. In the introduction, the author calls for a uniform system of documentation not only for following shock cases but also for comparison and analysis. Raven is hopeful that the mystery of shock may be soon solved by intensive study. This hope is too optimistic, as the complex

question of shock will ever challenge inquisitive workers until the millennium.

The terms "primary and secondary" are retained but Blalock's classification is urged as a basis of clearer differentiation. The cause of primary shock is attributed to the activity of the nervous system. If the blood pressure does not return after a few moments of secondary shock is present and transfusion is indicated. Harmful psychological influences are to be combated and the patient reassured. Vasoconstrictor drugs are indicated if an active vasodilatory substance is known to be present. The treatment and resuscitation methods should be instituted early so as to minimize the sequelae of secondary shock. The author then cites the clinical picture of secondary shock and adds data on the crush syndrome in which signs of renal failure such as decrease in urinary output, the presence of albumin and blood casts, and increase in blood urea and blood potassium together with rise in blood phosphorus and fall in plasma chlorides manifest themselves. A photograph depicting the crush syndrome is used as a frontispiece and a chart illustrates the use of plasma and corticoids (adrenal cortical extract). Postmortem findings are those of sufficing, extensive muscle necrosis, and degeneration of renal tubules. In the chapter on "The Pathology of Secondary Shock" the author wisely states that the theory cannot be expected to explain the complicated interplay of the various factors. The usual theories of causation of shock are reviewed, such as fluid loss, toxin, etc. In discussing blood changes Raven fails to make the jump that as a result of decreased blood volume, changes result in the blood due to the ingress of cell water which in themselves are wholly abnormal and impair normal physiological function. Barcroft's classification of anoxia is given and due stress is laid on Haldane's teaching. Anoxia not only stops the machine but cracks the machinery. Enough work that capillary stasis from oxygen deficiency is irreversible after 5 minutes is briefly recalled. The relation of the adrenal cortex to shock is reviewed but not clarified. The fact that it controls several of the variables in shock needs emphasis. One reason why this form of therapy has not advanced is due to the failure of employing the recognized laboratory tests which measure fluid and salt concentrations. Due emphasis is given to blood transfusions in the restoration of blood volume and the employment of plasma or serum in those instances when properly matched blood is not available. Chapter VII is a concise presentation on the "Methods of Oxygen Administration." The methods of blood and plasma transfusions are well illustrated portraying the types of apparatus used in the Army and in the Emergency Medical Service. Why warming the blood before administration is necessary is not stated. A convenient method of preparing liquid plasma is illustrated. The preparation of dried plasma by the method of Edwards, Kay, and Dawkins is depicted. This cannot compare with the preparation of plasma from the frozen state. The chapter on

"Anesthesia" is brief and to the point in that chloroform has made way for cyclopropane and pentothal induction. The warning against spinal anesthesia and Macintosh's insistence of maintaining a clear airway throughout the whole period of unconsciousness together with adequate oxygenation are stated.

The deferring of surgical intervention until the systolic blood pressure stabilizes around 100 is mentioned. This is not wholly correct for such operations should not be deferred if those factors which are causing shock are operating, such as a bleeding artery or a swelling limb resulting from inadequate immobilization of fractures. Under such conditions, the operation and the resuscitation should go on together. The teachings of Larry and the experiences of the last war are clear that the longer the operation is deferred the higher the mortality.

There are 79 references and the volume is well indexed.

JOHN SCUDDER

THE text of *The Antigonadotropic Factor, with Consideration of the Antihormone Problem*<sup>1</sup> by Zondek and Sulman, while dealing primarily with the antigonadotropic factor, embodies an extensive and complete résumé of the voluminous experimental data obtained in previous studies of the antihormone problem. Each phase has received separate and detailed consideration by comparison of the original data and theories with subsequent evidence much of which has been contributed by Zondek and Sulman themselves.

While the evidence presented is essentially experimental, clinical studies have been included in an effort to establish the validity of the theory and to ascertain its clinical significance.

The conclusions presented by the authors, which are of greatest significance to the clinician, suggest the following: (1) definite antihormone factors do exist, (2) these factors are not hormones or antibodies but they must be classified as immune bodies of a character hitherto unknown in serology, (3) only protein containing hormones, especially of the pituitary and of the adrenals, have been known to evoke the formation of "antihormones", (4) hormones of the steroid group (i.e. testosterone, androsterone, estrone, progesterone, adrenosterone, corticosterone), do not produce antihormone factors and the possibility need not be considered in protracted therapy with these substances, (5) the production of antihormone factors need not be considered in protracted therapy with insulin, adrenalin, thyroid hormone, pitressin, or pitocin, (6) a certain degree of refractoriness has been obtained by the administration of adrenal cortex, of the hypophyseal gonadotropic, and thyrotropic factors, and of the parathyroid hormone, (7) the production of antigonadotropic hormone factor must be considered in protracted therapy. Clinically the administration of actual pituitary gonadotropic substance and of preg-

nant mares' serum is most likely to produce these factors while preparations from pregnancy urine (prolan, i.e. chorionic gonadotropic substance), menopause urine, or normal male urine have not been found to produce antigonadotropic factors. The authors suggest as a precaution that pituitary gonadotropic or pregnant mares' serum preparations should not be administered over a period of time exceeding 2 to 3 months and that if continued therapy is indicated a prolan preparation be substituted. Finally, the authors emphasize the warning that *protracted treatment with gonadotropic hormone regardless of its source may ultimately induce physiological as well as morphological injury to the hypophysis*.

PHILIP F. SCHNEIDER.

THERE are two schools of thought on the most effective type of book on baby care to put into the hands of a mother. Some physicians believe that the most useful book is that which presents a few general principles of physical and mental health, in such a way that they may be understood and accepted. They feel that too much concentrated information tends to confuse and frighten the mother, so that like the proverbial medical student she sees things that are not there.

Others believe that a good nursery guide should contain full instructions for every crisis, major or minor, that a mother might meet. Dr Kenyon's well known book<sup>2</sup>, now in its third edition, is an excellent example of the latter.

Beginning with a chapter on prenatal care of mother and child, it gives up-to-date and specific instructions on the health, care, feeding, and training of the baby during the first 3 years of life. The material is advantageously presented on a month-to-month basis, so that the mother may easily find in one place the particular advice about her baby that is suitable for its age.

In addition to questions of nursery equipment, clothing, hygiene, infant feeding, diets, exercise and habit training, the book discusses such subjects as tuberculosis, communicable diseases, the development of chemotherapy, the treatment of emergencies and first aid. In peacetime, one might wonder whether some of these subjects might not produce anxiety in an inexperienced mother. In wartime, with doctors growing scarcer, they may be unusually valuable on the family book-shelf.

MARY M. ALDRICH

THE book, of 261 pages, entitled *Atlas of Ovarian Tumors*<sup>3</sup> by Dr Gemma Barzilai, is beautifully done. The illustrations, many of which are in colors, are excellent. Many of them are taken from slides used by the author in teaching at the University of Padua. Material used in preparing the book was also obtained in Vienna, Istanbul, and Milan. Later

<sup>1</sup>HEALTHY BABIES ARE HAPPY BABIES. A COMPLETE HANDBOOK FOR MODERN MOTHERS. By Josephine Hemenway Kenyon M.D. 3d rev. ed. Boston: Little, Brown & Co. 1943.

<sup>2</sup>ATLAS OF OVARIAN TUMORS. By Gemma Barzilai M.D. With a preface by Fred W. Stewart M.D. New York: Grune & Stratton 1942.

<sup>3</sup>THE ANTIGONADOTROPIC FACTOR WITH CONSIDERATION OF THE ANTIHORMONE PROBLEM. By Bernhard Zondek and Felix Sulman. Baltimore: The Williams & Wilkins Co. 1942.



work was done by the author at the Woman's Hospital in New York City.

In a work, the principal purpose of which is to present reproductions of microscopic preparations, the text is relatively brief. The legends found under the illustrations are sufficiently full to be adequately informative. The text is well done and conforms to the accepted ideas of gynecological pathology. The author is to be commended in having produced a

valuable addition to present day literature of gynecological pathology.

The reviewer agrees with the statement of Dr. Stewart in the preface, Dr. Barnhill has written a volume useful for pathologists and clinicians, and timely, modern, complete and excellently illustrated. It should be an essential part of every library even remotely concerned with the literature of gynecology.

W. C. DIXON.

## BOOKS RECEIVED

Books received are acknowledged in this department, and each acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

**A STUDY OF ENDOCRINOLOGY, PARADALPTEROSIS, ENDOCRINOLOGY, AND PERITONEO-OMALIAN SCLEROSIS. A CLINICAL AND PATHOLOGIC STUDY.** By James Robert Goodall, D.B.E., B.A., M.D., C.M., D.Sc., F.R.C.S. (Hon.), F.R.C.O.G. Philadelphia, London, and Montreal: J. B. Lippincott Co. 943.

**FIRST AID, SURGICAL AND MEDICAL.** By Warren H. Cole, M.D., F.A.C.S. and Lieutenant Colonel Charles B. Fournier, 4d ed. New York and London: D. Appleton-Century Co. 943.

**ESSENTIALS OF INTERNAL MEDICINE.** By C. O. Sappington, M.D., Dr. P.H. Philadelphia, London, and Montreal: J. B. Lippincott Co. 943.

**TRANSACTIONS OF THE AMERICAN GYNECOLOGICAL SOCIETY. Volume 67 for the Year 1942.** Edited by Howard C. Taylor, J. M.D. St. Louis. The C. V. Mosby Co. 943.

**UROLOGY IN GENERAL PRACTICE.** By Nebe F. Ockerblad, B.S., M.D., F.A.C.S. and Hjalmer E. Carlson, B.S., M.D., F.A.C.S. Chicago: The Year Book Publishers, Inc. 943.

**WAR INJURIES OF THE CHEST.** Edited by H. Morrison Davies and Robert Coope. Edinburgh: E. & S. Livingstone 943.

**GOUT.** By John H. Talbot, M.D. Edited by Henry A.

Christian, A.M., M.D., LL.D., Sc.D. (Hon.) F.A.C.P., Hon. F.R.C.P. (Can.). Reprinted from *Oxford Lectures on Medicine* (15 the same page numbers as in that work New York, London, and Toronto: Oxford University Press, 943.

**AVIATION MEDICINE.** By Louis Hopewell Bauer, M.D. Edited by Henry A. Christian, A.M., M.D., LL.D., Sc.D. (Hon.) F.A.C.P., Hon. F.R.C.P. (Can.). Reprinted from *Oxford Lectures on Medicine* (15 the same page numbers as in that work. New York, London, and Toronto: Oxford University Press, 943.

**OVARIAN TUMORS.** By Samuel H. Golub, M.D. New York and London: Paul B. Hoeber Inc., 1942.

**A GUIDE TO PRACTICAL NUTRITION: A SERIES OF ARTICLES ON NUTRITION, SPONSORED BY THE COMMITTEE ON NUTRITION AND DEFICIENCY DISEASES OF THE PHILADELPHIA COUNTY MEDICAL SOCIETY.** Edited for the Committee by Michael G. Wohl, M.D., and John H. W. Ward, M.D. Reprinted from *Philadelphia Medicine*, 941-942. Philadelphia: The Philadelphia County Medical Society 1943.

**INJURIES AND FRACTURE TREATMENT IN PRACTICE.** By Kurt Cohen, M.D. Johannesburg, Union of South Africa: Witwatersrand University Press, 943.

**SKIN GRAFTING OF BURNS: PRIMARY CARE, TREATMENT, REPAIR.** By James Barrett Brown, M.D. and Frank McDowell, M.D. Philadelphia, London, and Montreal: J. B. Lippincott Co., 943.

**ATLAS OF OBSTETRIC TECHNIQUE.** By Paul Titter, M.D. St. Louis. The C. V. Mosby Co. 943.

# SURGERY

## GYNECOLOGY AND OBSTETRICS

*An International Magazine, Published Monthly*

VOLUME 77

AUGUST, 1943

NUMBER 2

### INTRAVENOUS HUMAN PLASMA AND SERUM THERAPY

#### The Cause of Reactions with Particular Reference to the Use of Concentrated Plasma and Serum

J M HILL, M D, and E E MUIRHEAD, M D, Dallas, Texas

THE remarkably low rate of reactions following the intravenous administration of properly prepared human plasma and serum has been one of the most important factors in the rapid development of this form of therapy. Many workers having extensive experience with normal plasma (29, 53), normal serum (27, 28) and dilute plasma (10) have reported such a low percentage of ill effects from the intravenous use of these solutions as to establish a degree of safety equal to or even surpassing other medications commonly given by veins. However, it has not been generally appreciated that concentrated plasma or serum may be administered by the same route with equal safety and in the opinion of the authors, with superior therapeutic effectiveness.

The advantages of concentrated plasma and serum as observed in the William Buchanan Plasma Center have been described and consistently advocated during the past 3 years in several reports (14, 18, 19, 35). In particular, the small package and the increased speed and simplicity of use of dried plasma packaged for administration in concentrated

form have been held to be of particular significance for military use (13, 15, 16). Accordingly it seems worth while to present a study of reactions based on extensive observations in the preparation and administration of concentrated plasma in order to do away with misconceptions concerning the safety of this type of therapy and to establish confidence in its use. In addition, it seems likely that the percentage of ill effects in patients following plasma therapy in general can be even further reduced by a greater understanding of the factors causing untoward manifestations.

Such factors may be related to any form of plasma or serum solutions, whether it be dilute (protein concentration, 3 to 4 grams per cent), normal (protein concentration, 5 to 7 grams per cent), or the concentrated form (protein concentration, 15 to 24 grams per cent). Since concentration of plasma will also concentrate any injurious agents present, care must be exercised so that the recipient is not adversely affected by the greater quantity of dissolved material that could be given per unit of time than with less concentrated solutions (normal or dilute).

We must point out, of course, that the observations made and conclusions drawn deal

From the William Buchanan Blood Plasma and Serum Center of Baylor University Hospital, Dallas, Texas.

only with concentrated plasma prepared as previously outlined (13 15 16). The salient features of these methods are (1) pyrogen free technique for preparation of all apparatus tubing and solutions (2) sterile techniques throughout checked by bacteriologic control studies (3) pooling of blood of all different types just prior to separation of plasma (4) bulk desiccation of plasma from the frozen state by the adtecac process (5) sterile transference of dry plasma to small final container.

In this study the various causes of reactions are considered in relation to four major possibilities (1) factors inherent in the plasma or serum before preparation (related to donor) (2) factors introduced into the plasma during the preparation (related to processing) (3) peculiarities or idiosyncrasies of the patient (related to the recipient) (4) faults in administration (related to indications contraindications, and mode of administration).

*Pyrogenic or chill-fever reactions.* The most common type of reaction, the pyrogenic or chill fever reaction is related principally to preparation although the recipient must also be considered, because sensitivity to the factors causing this type of response varies from individual to individual.

The typical pyrogenic reaction is characterized by a chill beginning 30 minutes to 1 hour after the injection followed by a sharp rise in body temperature of 2 to 5 degrees F (see Fig. 3). The fever subsiding rapidly is usually back to the pre-reaction level in 3 to 4 hours. The patient may experience backache, headache, apprehension and anxiety and may vomit. There are milder types of such reactions with or without chills, with lower temperature elevations and with or without subjective manifestations. In exceedingly rare cases, the reaction may be very severe with persistent hyperpyrexia and terminally a shock like state resulting in death. We have never encountered this malignant reaction following plasma or serum therapy.

The agents responsible for these reactions termed pyrogenic substances, or pyrogens are produced in water by the growth of several bacteria. As early as 911 Weichselmann and Hort and Penfold pointed out that febrile

reactions were due to contamination of distilled water used in preparing intravenous injections. These observations were somewhat neglected but the work of Seibert and co-workers (16 21 45 57) put the concept of pyrogens on a firm basis. Since that time many observers (Titus and Dodds Rademaker Perkins Milbert Banks Nelson Co Tul and co-workers and Walter) have reached similar conclusions.

Present knowledge of pyrogens may be summarized briefly. These bacterial products (and possibly other protein or protein-like substances) cannot be destroyed by the ordinary autoclaving technique unless prolonged over 7 hours or much higher temperatures are employed. Proper distillation in special spray proof stills (41) is the most practical and commonly used method for obtaining pyrogen-free water. Pyrogens may also be removed by adsorption with charcoal sufficient filtration through Seitz packs, or by passing the water through a 300 second Zsigmondy membrane filter (6).

Pyrogens are exceedingly soluble and if present on a surface (rubber tube syringe or other equipment) they will be readily dissolved by water running over these surfaces. The dose required to produce a reaction is small but varies as there appears to be a variable individual susceptibility to a given dose of pyrogens (11).

The plasma and serum service at Baylor University Hospital (William Buchanan Center) presents an opportunity for a comprehensive survey of reactions because it has been almost entirely a concentrated plasma and serum service since its inception 3 years ago. Due to satisfactory clinical and experimental results following the use of these concentrated solutions and because of the co-operation and enthusiasm of the practicing physicians of Dallas and vicinity a great deal of information concerning the use of concentrated plasma and serum has been obtained during these 3 years.

In our analysis of reactions related to these concentrated solutions it should be noted that these injections varied from 50 to 300 cubic centimeters as single doses however 50 to 100 cubic centimeters of concentrate given in

Name J. E. D. Male Age 42 Hospital No. 3279 BB

Service of Dr. \_\_\_\_\_ Admitted 11-17-40 Interne, Dr. \_\_\_\_\_

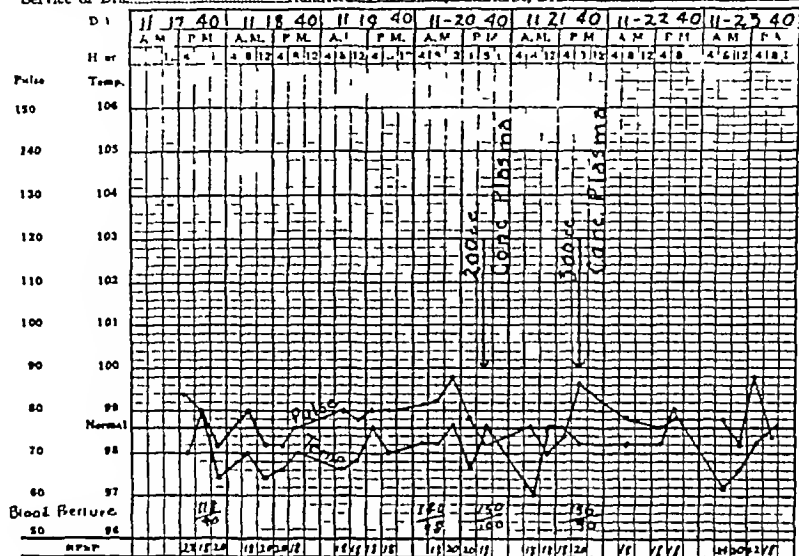


Fig 1 Diagnosis glomerulonephritis with nephrotic syndrome. This case demonstrates the appearance of temperature and pulse chart when no reaction occurs. Notice no change in these two curves following the concentrated plasma injections as compared to the same curves on the days before and after the injections. There was slight hypertension which was not altered by the injections. The plasma was given to encourage diuresis, 200 and 300 cubic centimeters of the concentrate as separate single doses.

1 to 15 minutes' time constituted the usual single dose. During the 3 years' period of study plasma concentrations varied somewhat with plasma proteins ranging from 15 to 24 grams per cent. Such doses are equivalent to 200 to 400 cubic centimeters of normal plasma. With this rapid injection of a concentrated solution an innocuous product is more necessary than when more dilute solutions are given. It is also true that a low reaction rate in relation to concentrated plasma can be taken to represent strong evidence supporting the method of preparation of the product. We also believe that information regarding these solutions may be applied to the entire plasma and serum field.

The reaction study includes only the patients in Baylor Hospital who received concentrated plasma or serum although it is estimated that a larger number of patients received such plasma through our state wide service. It was thus possible for one of us (E E M) to check each chart of 520 patients receiving 1,160 separate injections of concentrated plasma or

serum, in an attempt to standardize the appraisals of the reactions as much as it was possible

Information concerning the age, sex, diagnosis, number of injections, total amount given and ill effects resulting from the injections was recorded on each case. The temperatures, pulse, and respiration before and after the injection were checked. An elevation in the fever curve shortly after the injection up to 1 to 2 hours, was considered a reaction, except when the temperature change conformed exactly with temperature changes on the days before the injection (see Figures 1, 2, 3, 4). The febrile and urticarial reaction rates are presented in Table I.

TABLE I—FEBRILE AND URTICARIAL REACTION RATES—1,160 INJECTIONS—520 CASES

Type	Number	Percentage
Pyrogenic	14	1.2
Questionable pyrogenic	4	0.344
Total pyrogenic	18	1.55
Urticarial	6	0.51
Total pyrogenic and urticarial	24	2.06

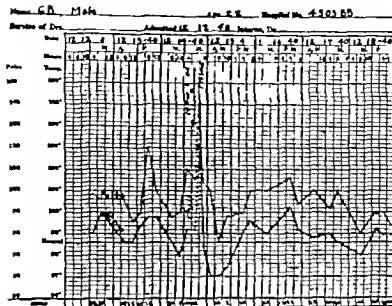


Fig. Diagnosis: second degree burns, left arm, neck, and chest. This case demonstrates typical pyrogenic reaction following concentrated plasma. Notice the sudden effects. The reaction begins with severe headache, aching in the bones, generalized malaise immediately after the injection. One hour and forty-five minutes later the temperature is elevated from 99.6 to 101.5 degrees F and the pulse rate rose to 40 beats per minute from previous level of 100. There is severe chill hour after the administration. Five hours after the injection the temperature is 101.5 degrees and the pulse rate 140. This is followed by short period of subnormal temperature and then complete recovery. Notice that the temperature and pulse curves are approximately the same on the days before and after the reaction.

The 14 typical evanescent pyrogenic reactions gives a reaction rate of 1.2 per cent. In 2 cases of this group just before the plasma was injected the patient received 1000 cubic centimeters of saline solution. Which of the two solutions caused the reaction could not be determined so both reactions were included in the plasma group. In 4 other instances the temperature elevation following concentrated plasma was greater than the usual elevations for that day but conformed well with the previous diurnal temperature changes. These 4 responses have been termed questionable pyrogenic reactions (0.34 per cent). This makes an overall total of 1.55 per cent for the incidence of pyrogenic reactions.

There are many reasons to believe that the main cause of these few reactions resided in the water used to dissolve the plasma and in 1 case sterile but not pyrogen free water was used by mistake to dissolve the plasma. This

idea is also supported by the fact that wide fluctuations have occurred in the whole blood transfusion service apparently related to variations in the preparation of the distilled water and its use in preparing equipment. Nevertheless, the concentrated plasma febrile reaction rate (1.55 per cent) is significantly lower than that of the blood transfusion service (5.18 per cent in 2139 transfusions during the year November 1941 to November 1942). Furthermore our belief that water was responsible for the reactions is supported by the fact that at Jefferson Medical College where autovac plasma is being given in concentrated solution, Jones and co-workers (21) have observed only 3 reactions in 1,600 injections of concentrated plasma. Since our reaction study includes the entire period of concentrated plasma production at Baylor Hospital from the inception of the service it includes the development periods when operations were at

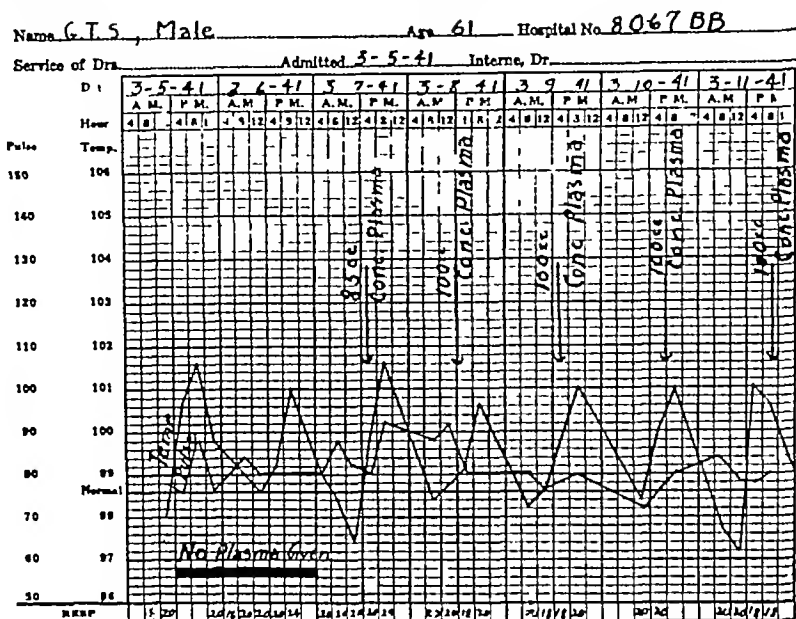


Fig 3 Diagnosis carcinoma of colon with metastasis to liver, hypoproteinemia. This case is presented in order to point out that elevations of the temperature (upper curve with daily peaks) following concentrated plasma which conform exactly in time of occurrence and degree with previous temperature changes do not represent reactions. This patient had an elevation of the temperature to 101 degrees F each evening, in variably demonstrated at 7 30 p m. The same temperature changes occurred on the 2 days before therapy was started. Notice that on the last dose presented (March 11, 1941) the same temperature elevation occurred before the plasma was given. There were no changes in the pulse rate, no subjective complaints as observed in the pyrogenic type of reaction, therefore, these changes are considered unrelated to the therapy and no reactions were recorded in this case.

times conducted under adverse circumstances. With present equipment and technique, we have reason to believe the present and future reaction rate will be considerably less than the overall rate of 1.55 per cent.

It should be possible to eradicate the pyrogenic type of reaction with the use of a proper pyrogen-free technique from the time the blood is collected to the preparation of the water and equipment used in dissolving the dry product. In order to assure an entirely pyrogen-free plasma solvent, we have lately added a step in its preparation. The water is distilled by a Barnstead type Q still, filter cell added, and the water immediately filtered through several Sertz pads and finally through a Mandler candle to remove any asbestos particles that remain. From the final filtration reservoir it is dispensed in bottles and immediately autoclaved.

*Urticarial reactions* are a type of allergic manifestation, characterized by itching, erythema, and multiple wheals of the skin. In severe cases edema of eyelids and lips may develop. The reaction appears immediately after the injection, usually generalized over the body. These reactions may be classified as related to factors inherent in the donor's blood and to peculiarities of the recipient.

As shown in Table I, 6 urticarial reactions have been observed in 1,160 injections, representing a rate of 0.517 per cent. This compares with a rate of 1.6 per cent for whole blood transfusions during the period between November, 1941, to November, 1942, involving 2,139 transfusions. This difference in favor of plasma appears significant in view of the large number of injections involved. The smaller urticarial rate for plasma may be ascribed to dilution of allergens in a given blood sample.

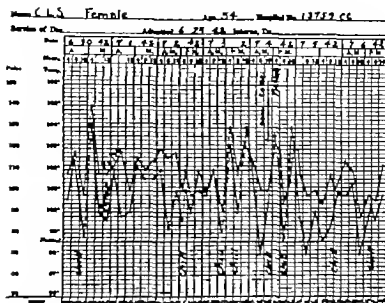


Fig. 4. Diagnosis febrile reaction following operation for intestinal obstruction. This case is similar to that shown in Figure 3 in that the changes in the temperature and pulse curves following concentrated plasma are not considered as reactions. Notice that the patient had exactly the same disturbances in the pulse and temperature at the same time of day on the day previous to the injection. Also the patient had several chills (fever before this time and even day after the injection). There are not many cases of this type in our series, so that even if they are included as reactions, the rate could not be substantially altered.

through its dilution in the stage of pooling of blood. It also indicates that the methods of processing employed did not cause changes or add substances responsible for this type of reaction.

Only 2 of the urticarial reactions were severe. The first consisted of a generalized pruritus 12 minutes after 150 cubic centimeters of concentrated plasma followed by wheals, edema of eyelids, transient increase in respiratory rate, and much discomfort and anxiety (see Fig. 5). The second severe reaction followed a 50 cubic centimeter dose in an emaciated 8 year old child with peritonitis. Six similar doses previously given were uneventful. The eighth dose given more slowly produced mild urticaria. Thereafter 4 doses given in normal or dilute form gave no reactions. Neither patient showed change in the temperature curve and both recovered completely.

The most peculiar reaction of urticarial type showed a narrow zone of wheals and

swarting of the skin over the right median cephalic vein from the level of injection of concentrated serum to the point where the vein passes beneath the deltoid muscle. This patient experienced no other allergic manifestations.

No lasting complications have occurred even with the severe urticarial reactions and rapid relief after hypodermic administration of 0.3 to 0.5 cubic centimeter of epinephrin solution 1:1000 was the rule.

Prevention of this type of reaction seems difficult because we cannot foretell which patients will be sensitive. Skin testing has not been satisfactory in our experience. Collection from donors in the fasting state has been suggested. This practice has not been followed in this center because of practical difficulties in taking donors from all sections of Texas. The use of large blood pools (25 to 50 pints) may help by dilution of allergen-containing blood however since urticarial manifestations following concentrated human plasma,

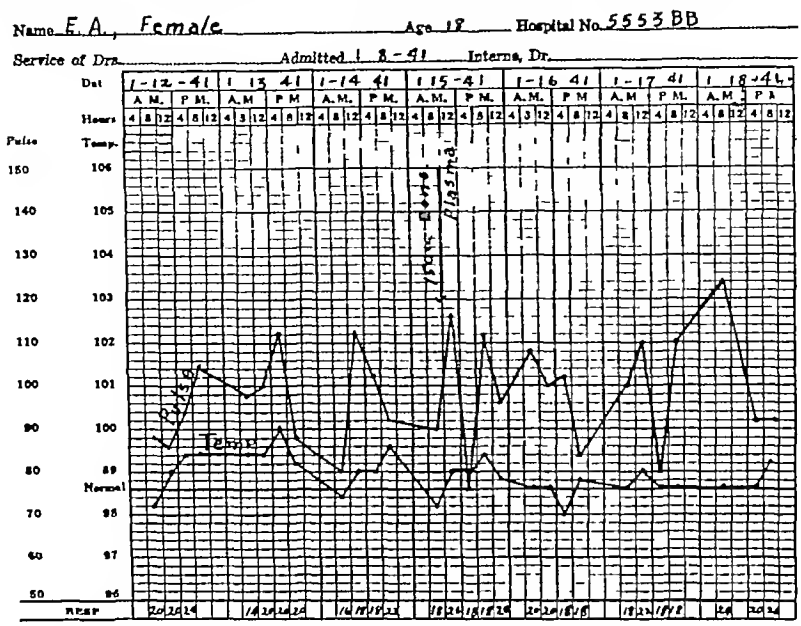


Fig 5 Diagnosis diabetes mellitus This case is mentioned in the text There was a severe urticarial reaction following 150 cubic centimeters of concentrated plasma as a single dose Notice no change in the temperature curve as compared to that of the previous 2 days There was a transient drop in the pulse rate but such changes occurred frequently in this case on other days The respirations were transiently increased The main changes were transient and related to the skin

as shown in this study, are unaccompanied by lasting or other serious results, they do not appear to be a serious objection to the use of plasma, concentrated or otherwise

*Citrate reactions* A type of reaction which has been extremely rare in the clinical use of concentrated plasma but which seems to be of marked importance in animal experimentation is the citrate reaction As we have previously indicated (18, 34) this type of response is due to the binding of calcium by the excess of sodium citrate in the anticoagulant solution into which the blood is collected initially The fully developed reaction is characterized by generalized tingling sensations, apprehension, dilation of pupils, carpopedal spasm, and tetany Chvostek's sign is positive and there is general rigidity Cyanosis was seen in 3 reactions and a transient apnea in a newborn infant

This type of reaction is related to three factors, processing (addition of citrate), mode of administration (rapid injection) and peculiarities of recipient (low blood calcium of

infants and hypocalcemic adults) The sodium citrate added during blood collection must be slightly in excess in order to assure complete binding of calcium as relatively un-ionized calcium citrate to prevent coagulation When the plasma is given as a concentrated solution, the citrate also is concentrated This means that more sodium citrate can be given per unit of time than is the case with normal or dilute plasma The speed with which citrate is given is very important in its relation to reactions, because citrate is very rapidly oxidized after entering the blood stream (43, 48) Even large quantities can be removed from the blood stream of experimental animals within a few minutes' time However, it is possible to introduce sodium citrate, especially if in concentrated solution, with sufficient rapidity to exceed the capacity of the oxidation mechanism The recipients calcium (ionic fraction) is progressively changed to the relatively un-ionized calcium citrate and the signs of calcium deficiency and development of the typical citrate reaction occur Obviously



the reaction can be produced more easily in an individual already hypocalcemic, or having a small total amount of blood calcium in relation to the dose given as in infants (or experimental animals). From these considerations it is apparent that it is not the total dose of citrate or even the speed of administration alone which must be considered but the amount of citrate per unit of body weight per unit of time.

The rarity of citrate reactions in our clinical experience indicates that concentrated plasma administered in 15 or 30 gram unit doses (50 to 100 c.c. volume) to adults in from 2 to 5 minutes time is a safe procedure. We have observed only 8 citrate reactions occurring in 4 patients. Five of the 8 reactions were observed in 2 of the cases. Three reactions were purposely induced to observe the effects and test antidotes. Three cases were children while the fourth was an emaciated white female age 18, who had a marked hypoproteinemia and hypocalcemia associated with steatorrhea. The citrate carpopedal spasm responds dramatically to intravenous calcium chloride or gluconate solution. The reaction may be prevented or stopped at will by 3 to 10 cubic centimeters of these solutions as demonstrated in 2 of the cases just cited. The reaction may also be prevented in these susceptible patients by slow administration of the concentrated plasma, thus allowing sufficient time for the removal of the citrate complex by oxidation. With concentrated serum of course these reactions do not occur and therefore, we prefer this type of concentrated protein solution especially for infants.

In simple hypoproteinemias we have not observed citrate tetany reactions even though total calcium is low in such cases according to McLean and Hastings. This seems to indicate that the ionic fraction alone is involved.

In experimental animals, the citrate reaction is most important in connection with the evaluation of the use of concentrated plasma as we have previously reported (2). When the human size syringe (50 to 100 c.c.) is used on the relatively small animal (dog) it is very easy to give doses of plasma (and citrate) which are huge in relation to the total ionic calcium in the blood stream. For example

100 cubic centimeters of concentrated plasma given (in a short period of time) to a 10 kilogram dog in 2 to 5 minutes is comparable to 800 cubic centimeters of concentrated or 3 200 cubic centimeters of normal plasma administered to an 80 kilogram human in the same time interval. Obviously such doses are scarcely comparable to those ordinarily given to humans clinically. Ivy and his co-workers have recently stressed the importance of citrate as a deleterious factor based on extensive experiments in dogs. The dosage per unit of time was large and not comparable to the unit dose of concentrated plasma which we have used for humans. It is unfortunate that this important factor has apparently not been considered by workers who have obtained poor results with concentrated plasma in experimental animals.

In conclusion, citrate reactions are extremely infrequent in adults, are only possible when the quantity given per unit weight of recipient per unit of time is very large. Hypocalcemia of course greatly reduces the amount which may be given by the above standards. This type of reaction in our opinion does not constitute an objection to the use in adults of concentrated plasma or any other type of blood or blood derivative preparation containing citrate.

*Overloading the circulation (sudden hypercalcemia)* Overloading reactions may occur as the result of failure to observe the contraindications to the use of concentrated plasma but should not be blamed on the product since one of its chief therapeutic actions is to increase blood volume rapidly. In the presence of myocardial damage or cardiac embarrassment concentrated plasma or serum should not be given or when given the greatest precautions should be exercised. The prominent conditions in this category include impending or actual heart failure such as in coronary occlusion, constrictive pericarditis, valvular lesions and tumor masses constricting the great vessels.

It must be remembered that concentrated plasma unlike normal or dilute plasma causes a blood volume increase greater than the injected volume. With dilute plasma the volume increase by contrast is less than that

given due to loss of the saline fraction either into the tissues or through the kidney. In the case of concentrated plasma the amount of fluid withdrawn from the tissues depends on the concentration, and the final sustained volume increment depends on the total protein content. The shift of fluids and the volume increase occurs rapidly, within a few minutes' time.

In shock or hemorrhage, in the presence of oligemia, this sudden and sustained increase in blood volume is highly desirable, and there is no danger of overloading the circulation from increased volume. When a definite hypoproteinemia is present there are indications that a contraction (49) of the plasma volume exists. Again there seems little chance of increasing the volume too rapidly.

When overloading occurs, pulmonary edema may develop if the left ventricle is under greater strain than the right, but when the right fails congestive failure may ensue or be aggravated. The immediate treatment is withdrawal of blood from the patient. In cases of massive pulmonary edema concentrated plasma has been of benefit when a preliminary bleeding greater than the expected volume increment has been performed. The procedure seems justified only in cases not responding to the usual medical treatment.

*Fibrin embolism* Mayner and Strumia and McGraw (51) have reported fibrin embolism following infusion of normal plasma. This type of reaction is due to factors related to preparation and administration. Due to loss of carbon dioxide during desiccation, dry plasma gives an excessively alkaline solution when redissolved in distilled water, with a resultant hydrogen-ion concentration from 8.5 to 9.0. Protein (fibrinogen?) is precipitated at these levels with formation of fibrin like strands and gelatinous spheres.

Jones and co-workers apparently were the first to realize the importance of the adjustment of the hydrogen-ion concentration of plasma after desiccation. This adjustment was accomplished by filling the bottle containing dry plasma with carbon dioxide gas at atmospheric pressure. When water is introduced, the carbon dioxide is rapidly taken up by the alkaline plasma solution yielding a

solution with a hydrogen-ion concentration near normal levels (pH 7.6 to 7.8). Strumia (50) has accomplished the same result by dissolving the plasma in dilute citric acid solution.

We have found both methods to be satisfactory, although the use of carbon dioxide seems more physiological. With the standard vacuum bottle capping device commonly used, the carbon dioxide gas can easily be introduced after the air has been exhausted from the bottle by vacuum pump. The bottle of plasma is then further sealed within an atmosphere of carbon dioxide in a standard tin can. For small scale methods, citric acid may be preferred. We have used 0.35 per cent solution of citric acid to produce concentrated plasma (15 to 20 grams in 45 to 55 cc).

We have not encountered any reactions on our service which could be attributed to fibrin embolism, although it seems entirely possible that some fibrin may have been administered. Early in the development of our methods, the fibrinogen content of the plasma was greatly reduced by treatment with filter-cel<sup>1</sup> and Seitz filtration. Later this step was omitted, but a stainless metal filter was designed to be placed into the under surface of the rubber stopper of the plasma bottle to remove such fibrin. At present both the filter and adjustment of the hydrogen-ion concentration of the final plasma solution are used as safeguards.

*Hemolytic reactions* Recent papers have indicated the possibility that intravenous plasma therapy is attended by some danger due to a content of isoagglutinins or type specific substances A or B (25, 26, 40), incompatible to the recipient. Polayes and Squillace reported the case of a patient whom they considered to have had a hemolytic reaction following the administration of a bottle of commercial type of dried plasma. The plasma given in normal concentration had an agglutinin titer of 1:16 and was prepared by the usual method of pooling several plasma samples. Mahoney and associates have pointed out the danger of transfusion given in close association with administration of such agglutinin containing plasma. The giving of exceptionally large doses of plasma and the use of

<sup>1</sup>Diatomaceous earth filter aid

plasma in concentrated form would seem to increase this danger when plasma prepared in the ordinary manner without complete agglutinin removal is used.

Levine and State (25, 26) used skin reactions to test whether a given plasma preparation is toxic for an individual. They suggested that reactions might be due to injected type specific substances in the plasma with which the recipient is incompatible.

In defending the use of plasma prepared by the technique of pooling plasma samples, Thalheimer points to the safety of pooled plasma as demonstrated by the small number of reactions seen in world wide use. In his opinion plasmas with agglutinin titers of 1:312 or less can be safely administered regardless of recipients' type and gives evidence to show that pooled plasma may frequently exhibit titers up to 1:30, but not higher than 1:60.

One must certainly agree with Thalheimer that the safety of pooled plasma when given in normal concentration and not combined with whole blood has been amply demonstrated. Nevertheless further improvement in the safety of plasma preparations is desirable. It would seem that complete or near complete neutralization and removal of the controversial isohemagglutinins by pooling different types of blood would be the logical solution. In this connection one interesting factor has been overlooked. According to Schiff and associates the type specific substances A and B (agglutinogens) may or may not be present in an individual's plasma, and on this basis individuals are classed as secretors and non-secretors. A nonsecretor having no dissolved agglutinin in his plasma would be lacking one of the three mechanisms designated by Thalheimer for the neutralization of injected incompatible isoagglutinins. His blood cells and fixed tissue cells would be required to effect all of the neutralization. This would mean more isoagglutinin available for adsorption and action on red cells. It would seem important to investigate whether such individuals have a lower tolerance for incompatible agglutinins. Another consequence of the concept of Schiff would be that plasma from nonsecretors would not be useful in reduction of isoagglutinin titer during pooling since it

lacks the type specific A and B substances responsible for partial neutralization or so called suppression of agglutinins occurring in plasma pools. If all plasma units in a pool should chance to be agglutinin free (i.e. from nonsecretors) no reduction of agglutinin titer except through dilution effects would be expected.

Since any reasonably sized plasma or blood pool will contain relatively large quantities of all isohemagglutinins it seems difficult to believe that dissolved agglutinin (A and B substance) can escape neutralization in any quantity to act as Levine and State claim to cause reactions.

Because isohemagglutinins in plasma can be harmful in high titers and some doubt exists concerning their possible effects in the range usually encountered in pooled plasma, we have come to believe that a safer plasma results when neutralization is accomplished by pooling blood rather than pooling plasma. The agglutinins can be completely neutralized and removed by pooling the various types (A, AB, B, O) of blood in the same reservoir. After pooling separation is most efficiently and rapidly effected by De Laval separators (13, 15, 16). When such agglutinin-free plasma is used hemolytic reactions cannot occur. This neutralization it seems, would also eliminate reactions of the type described by Levine and State and considered by them to be due to type specific substances. All of our plasma has been produced by the blood pooling technique during the last 3 years. When blood that has been stored not longer than 48 hours is used and a low temperature is maintained during pooling a plasma having a low hemoglobin content (25 to 50 mgm. per cent) can be obtained.

We have frequently given agglutinin-free concentrated plasma prepared by our methods, in conjunction with whole blood transfusions of various types without ill effects. Further more no reactions of the hemolytic type have been observed since the beginning of our dried plasma service in 1939. In evaluating the use of concentrated plasma in respect to its safety it would seem absolutely essential

This removal or neutralization of agglutinins is demonstrated by negative agglutinations against A and B cells at dilution.

to consider whether agglutinin had been completely or only partially neutralized in its preparation

#### MISCELLANEOUS CONSIDERATIONS

*Hemoglobin* As previously stated, we have found no evidence that hemoglobin or methemoglobin in plasma causes reactions. We have given 15 to 32 grams of free hemoglobin in saline solution to 8 patients without alarming reactions. Others (1, 5, 12) have found that hemoglobin solutions containing far more hemoglobin than ever encountered in plasma preparations could be administered intravenously with impunity. Yomarkann, however, produced fever in rabbits by induced intravascular hemolysis. This method, of course, introduces other factors.

*Dehydration* Near critical dehydration entailing very large losses of water from the body (5,000 to 10,000 cc in an 80 kgm. person) is an infrequent occurrence found under special conditions of gastrointestinal fistulas, cholera, possibly in water deprivation during desert warfare, etc. Such losses may contraindicate the use of concentrated plasma or more properly stated indicate the urgent need of rehydration with water and salt. Concentrated plasma solutions are not dehydrating in the ordinary sense, since water is not lost by diuresis as in the case of hypertonic glucose but merely shifted from tissues to blood stream. Of course, in the overhydrated person with edema this shift of excessive tissue fluid does result in diuresis.

We have not observed any reactions to concentrated plasma which could be attributed to dehydration, and clinically we have observed to our own satisfaction that in most circumstances under which traumatic shock, burns, and hemorrhage occur there is sufficient fluid in the interstitial and intracellular compartments to dilute large doses of concentrated plasma or serum. If loss of skin turgor is not prominent, concentrated plasma can be given with confidence that adequate amounts of fluid are available for hemodilution without harm to the patient and in the case of shock with benefit to the circulation.

In order to investigate further dehydration in relation to concentrated plasma or serum

therapy, such plasma was administered to dogs in the state of near critical dehydration (loss of 7 per cent body weight) induced by glucose diuresis (33). These animals showed a shock-like state with decreased blood volume, hypotension, hemoconcentration, concentration of plasma proteins, weakness, and stupor. Concentrated serum by vein resulted in transient but definite benefit with permanent recovery if followed by water by mouth within 2 hours. Studies of blood volume, fluid distribution and proteins showed that concentrated serum in dogs is capable of withdrawing fluid from the tissues into the blood stream without adverse reaction even when dehydration approaches the near critical level.

*Contamination reaction* Earlier Strumia and McGraw (52) reported a few febrile reactions following normal plasma injections which were attributed to actual contamination by organisms. Rigid techniques and extensive bacteriological controls eliminated these reactions. This possibility is always present when liquid plasma preparations are stored for any length of time. No reactions of this type have been observed in this plasma service since we have stored plasma only in the dry or frozen state both of which conditions prevent bacterial proliferation.

*Minor problems* Patients have occasionally complained of a slight dull ache along the course of the vein when concentrated plasma is administered rapidly. By slowing the rate of injection this pain can be stopped. Since the hydrogen-ion concentration of the concentrated plasma has been adjusted as suggested by Jones and co-workers this ache over the vein receiving plasma has been eliminated. This fact is of considerable importance when concentrated plasma is injected intrasternally.

When concentrated plasma or serum is given into the subcutaneous or dermal tissues, it is quite painful for a short time. The pain soon passes and we have never observed a slough from this minor mishap.

In parturient women the administration of the concentrate has on occasions precipitated a low backache which lasts 2 to 8 minutes. This pain seems to be associated with uterine contraction.

In severe shock cases we have on occasions observed a transient hyperpnea following the rapid injection of the concentrate. The hyperpnea lasts 3 to 8 minutes and entails an increase in the respiratory rate such as from 18 to 24 respirations per minute. The phenomenon seems to be confined to patients with a lowered blood pressure and to those frequently semiconscious and has not appeared to be harmful. We do not know the cause of this occasional transient hyperpnea but it can be eliminated by slowing the rate of injection or by brief pauses during administration.

The rapid injection of concentrated plasma to patients having an oligemia has not been conducive to what has been termed "speed shock" (20, 22). We have on numerous occasions administered 50 to 100 cubic centimeters of the concentrate in 2 to 5 minutes time with no observable ill-effects. The condition termed bulk reaction (20, 22) seems similar to that discussed under the heading "Overloading of the Circulation."

Newhouse and Kendrick have described a drop in blood pressure following the administration of concentrated plasma in cases in shock. In several cases we have considered this change due to insufficient therapy in the inception of a blood pressure drop due to shock. In such patients additional therapy in adequate measure has always reversed this change. In dogs in deep shock a transient mean arterial pressure drop has been observed following 5 to 15 cubic centimeters of the concentrate given rapidly (5 to 10 seconds). The drop is usually of 5 to 20 millimeters and lasts 0.5 to 1 minute. After this drop the pressure is elevated to a level above the preinjection level. We have never observed this type of pressure drop in human patients possibly due to the fact that it would be difficult if not impossible to administer concentrated plasma at a comparable rate with standard syringes and needles. For example it would be necessary to inject 600 to 800 cubic centimeters of concentrated plasma within 1 minute to the average adult to attain a rate of administration comparable to the experiment here mentioned. This transient depressor effect has been studied and will be discussed in a separate report (36).

We have been unable to differentiate between concentrated plasma and concentrated serum from the standpoint of frequency of reaction production. All but one of the pyrogenic and urticarial reactions reported in Table I resulted from the use of plasma. Our experience with concentrated serum is relatively small, but we have administered both serum obtained by syneresis and that obtained by blood defibrination. In the latter procedure the fibrin is whipped out by a special device (17). In children, there is no doubt that concentrated serum is preferred, because the citrate reactions are not encountered following its use.

It is believed by most workers that fresh serum, obtained by syneresis, is conducive to reactions but serum over 2 to 3 weeks old is not. We are not in a position to discuss this point but we can state that fresh serum obtained by defibrination dried by the adevac process dissolved in distilled water and given in concentrated form has not produced reactions in our hands. When Seitz filtration is employed in the preparation of plasma, a partially defibrinated product is obtained which likewise has not been conducive to reactions.

#### CONCLUSIONS

1. Different types of reactions with particular reference to concentrated plasma are discussed.
2. Reactions are classified according to causative factors namely factors inherent in plasma or serum factors introduced during the preparation factors associated with faulty administration including contraindications, and peculiarities or idiosyncrasies of the recipient.
3. Properly prepared concentrated plasma is safer than whole blood transfusions.
4. Although plasma prepared by pooling after separation of erythrocytes carries very little risk greater safety can be obtained by pooling of blood of all different types prior to separation.
5. The reaction rate of plasma prepared in this center is presented. Preparation consists of (a) low temperature pooling of whole blood (b) separation with two stage continuous



# IMPLANTATION OF THE HEPATIC DUCT INTO THE DUODENUM OR STOMACH

LESTER R. DRAGSTEDT M.D. Ph.D. ORMAND C. JULIAN M.D. Ph.D.  
J. GARROTT ALLEN M.D. and FREDRICK M. OWENS, J. M.D. Chicago, Illinois

**A**NASTOMOSIS between the hepatic duct and the duodenum or stomach may become necessary as a result of operative injury to the common bile duct in the treatment of gall stones or following resection of the common bile duct for carcinoma. Many different methods for securing such an anastomosis have been devised and described but a review of this literature does not come within the scope of this paper. Many of the methods are unsatisfactory because of technical difficulties or subsequent stenosis. The procedure adopted in the two cases to be described appears to present certain advantages in these respects over those in common use and, since the principle of the method has not, to the authors knowledge, been heretofore described, this report seems warranted.

**CASE 1.** U. I. No. 22 005. A female, aged 35 years, was first seen by us on September 20, 1940. Details of the history and findings are omitted except for certain relevant items. She had been operated upon elsewhere January 24, 1934, by competent surgeon and a cholecystectomy had been performed. The operation was stated to have been accomplished without unusual incident. Symptoms suggestive of biliary colic had been present for the previous 9 years. These were entirely relieved by the operation and the patient states that she felt well for a period of 6 months. When she first noticed jaundice and generalized pruritus. Vitamin K and bile salts were administered, but the jaundice steadily increased during the next 3 months and severe colic-like pains appeared in the right upper quadrant of the abdomen on September 8. When seen by us this patient was very deeply jaundiced, the icteric index was 85 and there was no bile in the stools. The prothrombin time was normal, doubtless due to the continued ingestion of bile salts and vitamin K. A diagnosis of obstructive jaundice was made and operation was performed on September 7, 1940. The gall bladder common bile

duct, and free portion of the hepatic duct were all missing. Dense scar tissue on the under surface of the liver was dissected free and the greatly dilated intrahepatic portion of the bile duct as finally opened. This yielded about 20 cubic centimeters of a colorless mucinous fluid. Since the opening was flush with the liver surface and the region relatively inaccessible, the problem of making a satisfactory anastomosis with the gastrointestinal tract appeared at first quite formidable. Recourse was made to a method that one of us (L. R. D.) had previously used with success in experimental work on dogs. A rubber catheter (No. 8 French) the largest that could be introduced, was inserted snugly into the hepatic duct and passed upward into the liver for a distance of about 3 centimeters. The duodenum had been freely mobilized in the previous dissection in searching for the common bile duct. The catheter was then placed against the anterior wall of the second portion of the duodenum as illustrated in Figure 1. The duodenum was folded over the catheter for a distance of centimeters with silk sutures in a manner similar to that employed in the Wilder enterostomy. The free end of the catheter was introduced into the lumen of the duodenum and then cut again by means of a stab wound 4 centimeters distally as indicated in Figure 2. Both the entrance of the catheter into the duodenum and its exit were tightly closed, the latter being reinforced by generous tags of omentum. Two stay sutures were then placed in the scar tissue, one on either side of the port re-into the hepatic duct. The duodenum was sutured along the catheter against the bulum of the liver and held in place by the stay sutures, as illustrated in Figure 3. The catheter was thus completely covered. The abdomen was closed in the usual manner and the catheter brought out through the incision. The drainage from the tube remained straw colored for several hours, then became definitely bile tinged and progressively darker until normal greenish bile drained freely. Convalescence was satisfactory except for moderately severe wound infection. The catheter was removed in 14 days, bile immediately appeared in the stools, but the icteric index remained abnormally high for 3½ months. Jaundice then disappeared and the patient has remained well to date (December 1941) or over 2 years.

In view of the operative findings the long period (6 months) of good health and freedom from jaundice after the cholecystectomy is

From the Department of Surgery of the University of Chicago. Read before the Chicago Surgical Society, December 1941. This work has been aided by grants from Mrs. Emma F. G. Adams and the Douglas French Foundation for Medical Research of the University of Chicago.

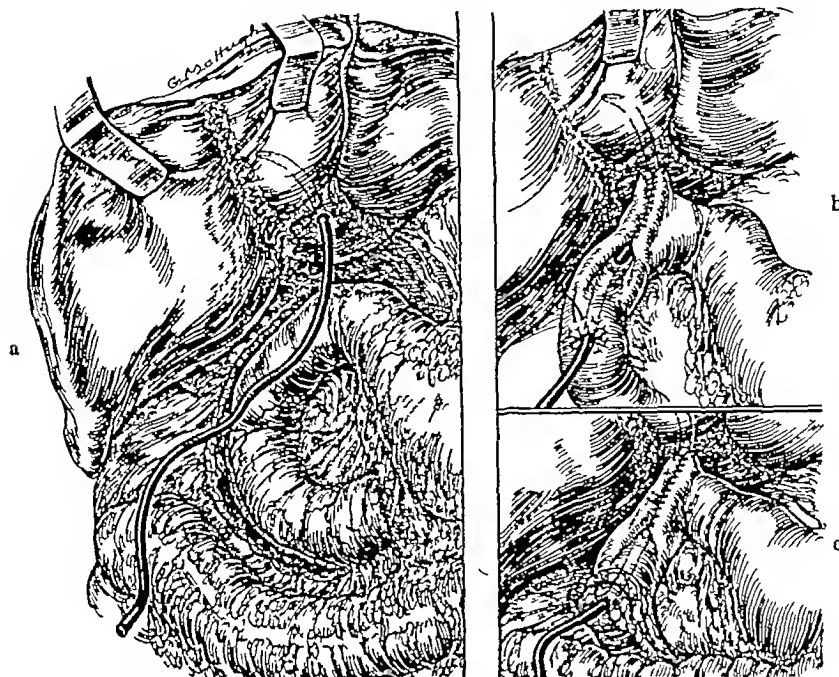


Fig 1 Illustrating a method for making an anastomosis between the intrahepatic bile duct and the duodenum

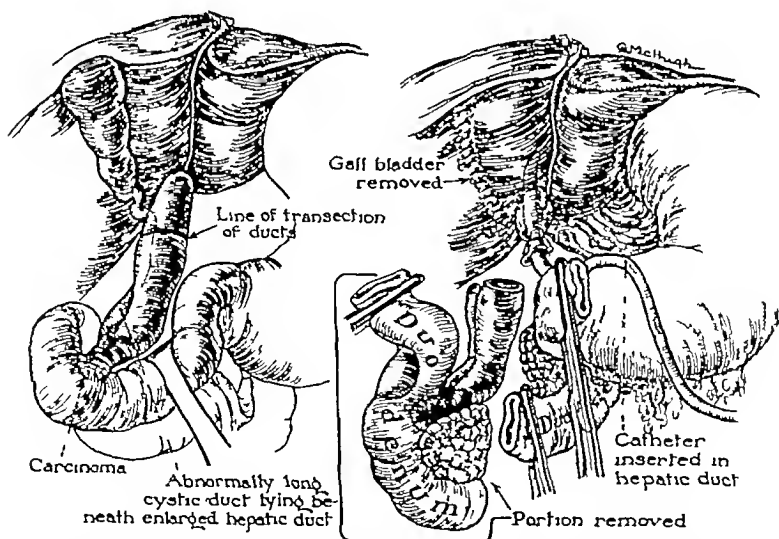


Fig 2 Drawing illustrating carcinoma of the common bile duct and cystic duct which emptied abnormally low into the common duct



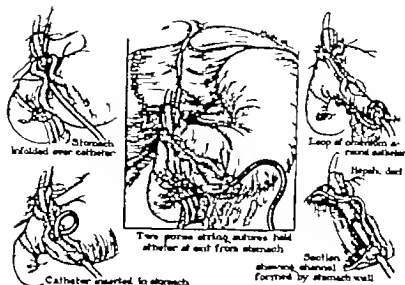


FIG. 3. Drawing illustrating method of reconstruction after pancreatoduodenectomy and for implantation of the short hepatic duct into the stomach.

interesting. It seems probable that the ducts were not directly damaged at this operation but that some other factor possibly interference with the blood supply to the ducts, was responsible for their subsequent gradual disappearance with the onset of obstructive jaundice. The method of repair here illustrated is technically the easiest of those with which we are familiar and the free external drainage of bile is reassuring from the standpoint of liver function in the immediate post operative period.

CASE. Unit No. 370766. Male, aged 67 years, entered the A. M. Billings Hospital November 24.

The details of the history and findings are omitted except for certain relevant items. There was a story of progressive painless jaundice and weight loss of 50 pounds during the previous months. The liver was markedly enlarged, the stools were clay colored, the icteric index was 60, the prothrombin was 86 per cent of normal, and moderate anemia was present. A diagnosis of obstructive jaundice probably due to cancer of the head of the pancreas was made and operation was performed on November 26, 1941. The liver was markedly enlarged, dark green in color firm and nodular. The gall bladder was collapsed and contained a small amount of thick gray fluid. The common and hepatic ducts were enlarged and tensely distended at a point where the duct entered the pancreas. The tissues here were hard and fibrous and tentat-

diagnosis (subsequently confirmed) of cancer of the common bile duct was made. Pancreatoduodenectomy was performed and the hepatic duct implanted into the stomach as illustrated in Figures 2 and 3.

Recovery was satisfactory. Bile drained freely from the tube. The hepatic duct until it was removed weeks later. A duodenal fistula then developed and persisted. The subsequent course was characterized by progressive nutritive impairment, weight loss, and cachexia, in spite of almost daily transfusions of blood, plasma, or amino acids. Death occurred March 29, 1942, or 4 months from the operation. A autopsy revealed extreme emaciation, complete absence of subcutaneous and depot fat and biliary cirrhosis, but without fatty infiltration of the liver. The pancreatic duct as completely occluded, dilated, and the remaining pancreas atrophied and fibrotic. This trophy admitted to the celiac tissue the islets were normal.

The absence of fatty infiltration of the liver in this case is significant in view of the complete occlusion of the pancreatic ducts. No pancreatic juice could enter the intestinal tract. This finding is in harmony with our results in the dog following ligation of the pancreatic ducts, and suggests that lipocal deficiency is not a prominent feature at least in the immediate postoperative period. The emaciation can be accounted for on the basis of the duodenal fistula, the absence of pancreatic digestion and the impairment of liver

function which doubtless interfered with the utilization of the plasma and amino acids supplied. The plasma protein concentration persisted at a low level and did not respond to parenteral amino acid therapy. The case is presented as offering a satisfactory method of dealing with the hepatic duct after pancreatoduodenectomy, but raises the question—should not the pancreatic duct be reimplanted into the intestine in this operation? Many of these patients with long standing biliary obstruction are handicapped by serious impairment of liver function and for this reason may not respond satisfactorily to the intravenous administration of plasma or amino acids. The complete removal of pancreatic digestion by ligation of the pancreatic ducts produces an additional handicap to adequate nutrition which in some cases may determine

the issue. The severed pancreatic duct in the dog may be readily implanted into the small intestine by the method described here for the hepatic duct. In this case, however, infolding is omitted. A small ureteral catheter is tied into the pancreatic duct, made to traverse the small intestine by means of small stab wounds and then led to the exterior. After 4 or 5 days the catheter is removed and the high secretory pressure of the pancreas maintains the new opening into the intestine. It is possible that in some cases this method might also succeed in man. The duodenal fistula doubtless resulted from the anastomosis of the stomach with the horizontal portion of the duodenum, which is partly deficient in peritoneal covering. It would have been better surgical judgment to have closed the duodenum and made an anastomosis with the side of the jejunum.

# HEXESTROL

## A Comparative Study of Estrogens and Methods of Administration

JOSEPH G CROTTY, M.D., F.A.C.S. STUART A. SCHLOSS, M.D. and  
GEORGE LYFORD, M.D. Cincinnati, Ohio

THIS report culminates 7 years of experience gleaned from the treatment of some 358 patients with almost all of the estrogenic preparations that have been made available during the past 10 years. A critical review of these 358 cases yields some rather pertinent data as to which of the hormones has been the most effective in our hands, and some very impressive evidence as to which method of administration is productive of the most satisfactory results. In this series of patients we have used from time to time the estrones, the estradiols, emmenin and more recently the synthetic estrogens, stilbestrol and hexestrol. Before the advent of the synthetic hormones our policy had been to attempt to time the administration of the estrogens in such a way as to imitate the normal cyclic production of this hormone by the human ovary. This method of administration we have chosen to term "estrogenic therapy in phase" as opposed to continuous mass dosage wherein relatively large doses are given at regular specified intervals without regard to the physiologic hormone cycle with which nature seems to do so well. While we have accumulated impressive statistics on the "in phase" administration of the so-called "natural estrogens" in relatively small doses, unfortunately we have no data on such a method of administration of hexestrol, and diethylstilbestrol was given in this manner in so few cases that the results are not significant.

From the Department of Gynecology, University of Cincinnati College of Medicine, and the Gyn-Dysfunction Clinic of the Cincinnati General Hospital.

Read before meeting of the Cincinnati Obstetrical Society October 15, 1942.

Dr. Schloss, now Lieutenant, M.C., U.S.N. on active duty, is now, at the same time, exceptionally well trained gynecologist and member of the Gyn-Dysfunction Clinic of the Cincinnati General Hospital, died February 15, 1943, after short illness. He was an ardent advocate of the "in phase" method of administration, and the figures here compiled attest to the soundness of his teaching. J. G. C.

The pharmacologic and physiologic activity of the "natural estrogens" estrone, estradiol and emmenin have been so thoroughly discussed in the past that we shall merely tabulate our experience with these hormones administered "in phase."

TABLE I.—IN PHASE ADMINISTRATION

	Cases	Per cent	Mean treatment time, days
Symptoms free	62	45	5
Improved	5	36	4.6
Unimproved	24	8	4.5
Mean treatment time for group			4.7

The development of the stilbestrol series of estrogenic substances began with the demonstration by Dodds and Lawson in 1937 that anol (p-hydroxypropenyl) undergoes polymerization and yields traces of a highly active estrogenic substance one of the most potent of which is dihydroxy- $\alpha$ -beta-diethyl stilbene, or diethylstilbestrol. In clinical use however the administration of diethylstilbestrol was attended by toxic reactions exhibited chiefly as nausea and vomiting.

Further intensive research was carried on for other active polymers of anol in the hope of finding a compound with high estrogenic activity and comparatively low toxicity. Campbell, Dodds, and Lawson (3) isolated from anol a highly active polymer 4,4 dihydroxy gamma delta-diphenyl n-hexane which was identical with the hydrogenated form of diethylstilbestrol dihydroxy-diethylstilbestrol. These authors found that this latter substance which was called "hexestrol," in doses of 0.15 microgram gave an estrus response in 60 per cent of rats whereas a dose of 0.1 microgram gave a 20 per cent response. A dosage of 0.2 microgram caused full estrus in all rats. It appeared that in the rat hexestrol was more active than diethylstilbestrol in producing vaginal estrus.

Campbell and coworkers (4) further tested the biological activity in ovariectomized rabbits, male guinea pigs, and ovariectomized rats. Comparative activity of diethylstilbestrol, hexestrol, and estradiol was determined in the 60 rats, and it was found that hexestrol was most active, being slightly more active than diethylstilbestrol and 2.8 times more active than estradiol.

The first reported clinical study of hexestrol was made by Bishop and his associates. Their chief object was to determine threshold doses of diethylstilbestrol, diethylstilbestrol dipropionate, and hexestrol rather than to obtain a high percentage of satisfactory clinical results. Of 103 menopausal patients 63 were treated with hexestrol, 60 with diethylstilbestrol dipropionate. Relief was obtained in 91.2 per cent. Comparative clinical activity could not be established by this regimen, but the toxicity incidence, studied in 155 cases, was 21.6 per cent for diethylstilbestrol and the dipropionate, and 4.5 per cent for hexestrol. (In a private report appended to this publication, Bishop reports toxicity studies in a series of 83 patients treated with diethylstilbestrol, 20 with diethylstilbestrol dipropionate and 18 with hexestrol. Toxic symptoms developed in 22.9 per cent with diethylstilbestrol, 30 per cent with diethylstilbestrol dipropionate, and in none with hexestrol. The maximum daily dose of hexestrol in this series was 2 milligrams orally.)

The comparative estrogenic activity of hexestrol and diethylstilbestrol in the human has been studied by Freed who found that 3 to 5 milligram doses of hexestrol were necessary for satisfactory relief in a group of menopausal patients who had been controlled with 0.5 to 1 milligram of diethylstilbestrol. Thus the activity in the human of hexestrol was, according to this report, one-fifth that of diethylstilbestrol. Incidence of toxic reactions with hexestrol was about one-half that with diethylstilbestrol, the incidence in the latter being 15 per cent. Toxic reactions with hexestrol (nausea and vomiting) were mild and seldom necessitated withdrawal of the drug.

Bieren and Compton found in small series of patients with menopause, primary dysmenorrhea, and senile vaginitis that the activity of

hexestrol was only one-tenth that of diethylstilbestrol. On the other hand they found that in treating vulvovaginitis of children hexestrol was slightly more effective than equal doses of diethylstilbestrol. Some patients responded to large doses of hexestrol that had not responded to small doses of stilbestrol. Nausea was experienced in some, but it was of mild nature.

The discrepancy in estrogenic activity of hexestrol in the two latter reports indicate that much more study in larger series of patients is necessary before any definite statement as to the comparative activity of hexestrol and diethylstilbestrol can be made.

Aside from the results here discussed, little or no data are available regarding the pharmacology and toxicology of hexestrol. Preliminary results (8) of a recent investigation indicate the close similarity between the activity of hexestrol and stilbestrol. Assayed subcutaneously in olive oil by the method of Kahnt and Doisy 0.35 gamma of hexestrol was found equivalent to 0.4 gamma of either stilbestrol or alphaestradiol benzoate. These results compare favorably with those obtained by Campbell and associates (4). Hexestrol and stilbestrol administered in large doses every other day for a period of 3 months inhibited the rate of growth and weight increase in ovariectomized females, normal females, and male rats. The toxic changes observed were similar to those described by Teague. The adrenals were enlarged and dark brown in appearance, the hypophyses of many of the animals were hypertrophied, the gonads of both the male and female animals were atrophied, and the uterus and vagina resembled those of estrous animals. Pyometria occurred in some of the rats. Hexestrol and stilbestrol produce a like increase in the weight of the uterus of immature mice indicating a similarity in action. This action was also observed by Campbell (4).

On the basis of the available animal experiments it would, therefore, appear that the toxicity and estrogenic activity of stilbestrol and hexestrol are very similar.

One of the pitfalls in the evaluation of response to estrogenic therapy has always been the close similarity of the symptomatology of the menopausal syndrome and that of neuro-

circulatory asthenia and the various psychoneurotic states. Several clinics have from time to time substituted sterile oil or saline for the injectable estrogens and have noted relief from symptoms, comparable in many instances with the results obtained with estrones and estradiols. Another of the variables encountered is the very obvious fact that our private patients respond much more quickly and completely to estrogenic therapy than do their sisters in the free clinics and dispensaries. Several reasons have been given for this, the most universal being the economic reality that the private patient having to pay for her treatment, strives for release from medical expense as well as from her symptoms, and this in turn acts as a very definite psychic boost along the road to recovery. The return of good times and increased employment incident to war work has also been a great psychic aid to symptomatic relief. Patients who have responded indifferently in the past, quickly recover so that they can get easily available and remunerative work at nearby defense plants. Women whose husbands and sons have long been idle and on relief rolls, improve markedly as these unemployed begin to bring home pay checks which insure more and better food, entertainment and the other desirable things in life. Conversely some patients who were getting along quite well experienced marked exacerbation of symptoms when sons were drafted into the army or when military action was reported in areas where sons already in the services were known to be stationed. Unquestionably favorable or unfavorable psychic influences can alter greatly the response of these patients to our best attempts at effective estrogenic therapy.

Weather is another very definite factor which must be taken into consideration. We have noted much more difficulty in controlling symptoms of menopause during spells of high humidity and it is undeniable that the patient in the climacteric sleeps better, feels better and enjoys much more freedom from hot flashes, fatigue headaches and vertigo in cool dry weather than at any other season of the year.

As has been previously noted diethylstilbestrol was the first of the synthetic estrogens

to be produced for clinical use. The consensus has been that this preparation is an effective estrogen, whether given by the oral route by the application of ointments and suppositories, by the intramuscular injection of oily solutions, or by the implantation of crystals and pellets. It has been of great value in the relief of the untoward symptoms of the female climacteric, but favorable reports have also been forthcoming on its efficacy in the treatment of various other conditions in which a potent estrogen is indicated. Its use in the relief of essential dysmenorrhea has been favorably commented on by Sturgis, and Ross and Collins have found it effective in the treatment of gonorrheal vulvovaginitis and in the relief of vaginitis of the postmenopausal years. Much has presented conclusive evidence of the value of stilbestrol in the suppression of lactation, and its ability to decrease the insulin requirement of the diabetic in pregnancy has been reported by White and Hunt and in the menopause by Spiegelman. Many writers, notably Sevringhaus have reported favorably upon the efficacy of stilbestrol in the menopause. That it may be of value in the treatment of hyperemesis gravidarum seems not unlikely from the work of Smith and Smith who found that its administration along with progesterone had a definitely beneficial effect on the nausea and vomiting.

For the past 2 years we have been treating all patients with hexestrol by the method of continuous mass dosage.

For purposes of comparison our experience with continuous mass dosage using all estrogenic hormones except hexestrol is compiled in Table II.

TABLE II.—ADMINISTRATION BY CONTINUOUS MASS DOSAGE

	Cases	Per cent	Mean treatment time—months
Symptom free	7	5.35	8.3
Improved	5	40.35	6.5
Unimproved	4	37.8	7.8
Mean treatment time for the group			7.33

From the figures in Table II it will be seen that administration of all estrogens except hexestrol by continuous mass dosage produced only 15 per cent of symptom free results as

compared with 45 per cent by in phase administration, 38 per cent of complete failures as compared with 18 per cent, and a total satisfactory result (symptom free and improved) of 62 per cent as compared with 79 per cent for the in phase method. The latter also gave results in a significantly lesser treatment time, 7.35 months for continuous mass dosage and only 4.7 for in phase therapy.

Our experience with hexestrol by continuous mass dosage, summarized in Table III, shows a higher incidence of satisfactory results and a lesser incidence of complete failures than either of the previously detailed methods, with a treatment time not appreciably less than that of in phase administration. The latter still is superior as far as completely symptom free results however, with 45 per cent as compared to 28 per cent with hexestrol. It seems logical to suppose that hexestrol, administered by the in phase method, would be far superior to any type of therapy yet tried, and it is our plan to run such a series of cases with this new synthetic estrogen.

TABLE III—CONTINUOUS MASS DOSAGE  
(HEXESTROL)

	Cases	Per cent	Mean treatment time—months
Symptom free	31	28.2	5.5
Improved	61	57.3	5.5
Unimproved	10	10.5	5.3
Mean treatment time for group			5.4

In our series of cases on hexestrol, 130 patients have been treated for various gynecological complaints, these cases are distributed as follows: surgical menopause 55, natural menopause 55, senile vaginitis 3, amenorrhea 1, oligomenorrhea 2, metrorrhagia 2, dysmenorrhea 12 cases.

The menopausal symptoms encountered with percentage incidence were as follows: hot flashes 96.5 per cent, insomnia 57, 52.0 per cent, nervousness 52.47 per cent, fatigue 50.45 per cent, headache 49.44 per cent, emotional lability 20.18 per cent, arthralgias 17.15 per cent, vertigo 17.15 per cent, others 15.16 per cent.

**Results.** The total results in all types of cases have already been tabulated (Table III). The results in the individual case groups

are shown in Table IV—Results in Individual Case Groups.

TABLE IV—RESULTS IN CASE GROUPS

	Cases	Per cent	Mean treatment time—months
<b>Surgical menopause</b>			
Symptom free	13	27.0	7.25
Improved	30	62.5	6.25
Unimproved	5	10.5	5.4
Unsuitable for treatment	3		
Insufficient time for evaluation	4		
Treatment discontinued because of untoward effects (Nausea and vomiting, 2, nausea only, 5)	7		
Mean treatment time for group			6.4
<b>Natural menopause</b>			
Symptom free	9	16.7	3.75
Improved	33	68.7	4.7
Unimproved	7	14.6	5.3
Unsuitable for treatment	1		
Insufficient time for evaluation	6		
Treatment discontinued because of toxic effects (Nausea, 2, chills and urticaria, 1, headache and conjunctivitis 1)	4		
Mean treatment time for group			4.6

**Senile vaginitis.** Three patients with senile vaginitis were treated, 2 of them with quite satisfactory results. Only the oral route was used in these cases, but we are of the opinion that the use of hexestrol in the form of vaginal suppositories would have hastened and made more complete the clinical result.

**Amenorrhea.** Only 1 patient with amenorrhea was treated. While withdrawal bleeding of a very small amount was noted, this patient had previously been subjected to pituitary irradiation for this purpose, and it is impossible to evaluate the result. She has bled cyclically without hexestrol since the irradiation treatment.

**Oligomenorrhea.** Two patients with scanty menstruation were treated with hexestrol. One has been under observation only 2 months at the present writing and as yet no improvement has been noted. The other had been treated for 8 months with amniotin and 2 months with diethylstilbestrol. After 3 months of 10 milligram of hexestrol daily, she bled so profusely that another preparation had to be used to check the bleeding. She did not return to the clinic thereafter.

**Functional bleeding** Two patients with functional bleeding were treated. In 1 there was complete failure, and x-radiation was decided upon in preference to further trial with hexestrol. The second patient had apparently satisfactory improvement in one menstrual cycle but has not been under observation long enough to justify any claims.

**Dysmenorrhea.** In the treatment of dysmenorrhea, we have had some truly brilliant results, just as we have previously noted with diethylstilbestrol. We have reserved the use of hexestrol for the refractory case which has resisted the more commonly used analgesics and antispasmodics. The cases we have treated have been only the failures of other forms of treatment including dilatation and curettage, uterine suspension and presacral sympathectomy. Since the theory is that a large dose of estrogen, such as represented by hexestrol, inhibits the pituitary which in turn fails to bring about follicle maturation and rupture thus inducing anovulatory bleeding which is painless, we do not believe that it is to be recommended for widespread or continuous use. But for the clinician who wants to secure prompt symptomatic results so as to gain the confidence of his patient while he studies her case more carefully and at greater length, hexestrol is suggested for cautious administration under careful observation. Of the 12 patients treated, complete symptomatic relief was noted in 9. The 3 others were failures.

**Toxic effects** Toxic effects in the incidence listed below were noted in 23 cases. In only 11 cases were these severe enough to necessitate discontinuance of hexestrol: nausea only 13 cases, vertigo 4, nausea and vomiting, 2, epigastric pain 2, headache with conjunctivitis, 1, chills with urticaria, 1, making a total of 23. The 11 necessitating discontinuance were distributed as follows: nausea only 7 cases, nausea and vomiting 2, chills and urticaria, 1, headache and conjunctivitis, 1, making a total of 11.

**Dosage** The dosage of hexestrol was so variable that it is impossible to tabulate it in any kind of statistical form. Suffice it to say that the incidence of untoward symptoms from the drug bore no relationship to the dose-

age given. The amount administered has varied from 0.2 milligram every other day up to as high as 3.0 milligrams twice daily for the oral preparation, and 1.0 milligram from one to three times weekly for the intramuscular route. Toward the end of the series our tendency was to start our menopausal cases out on 3.0 milligrams by mouth daily and 1.0 milligram in oil twice weekly by the intramuscular route. This schedule was maintained until some amelioration of symptoms was noted, after which the dose was reduced gradually to the lowest amount compatible with a satisfactory symptomatic result. While in some cases this was accomplished with a dosage as low as 0.2 milligram every other day orally, the usual maintenance dose was 1.0 milligram orally daily. Intramuscular administration was continued at least once a week until we were sure the patient was getting a good symptomatic result, and in a few cases intramuscular medication alone was used as the patients seemed to respond better to this method of management. Whether this was due to the greater efficiency of intramuscular dosage, or to the greater psychic effect of this more impressive procedure must be left for conjecture, probably both factors play a part.

The 11 cases with untoward symptoms necessitating discontinuance of hexestrol are listed below together with the dosage used:

2. Nausea and vomiting 0.2 mgm daily orally only
1. Nausea and vomiting 1 mgm every other day
1. Nausea only 3.0 mgm daily orally
1. Nausea only 0.2 mgm daily
1. Nausea only 0.2 mgm daily
1. Nausea only 1 mgm twice daily orally
1. Nausea only 1 mgm twice weekly intramuscularly
1. Nausea only 0.2 mgm daily
1. Chills and urticaria 1.0 mgm twice daily orally and 1.0 mgm times weekly intramuscularly
- Headache and conjunctivitis 1 mgm times weekly intramuscularly

Of these 11 cases in only 1 the patient with chills and urticaria, can the dosage be said to have been large. In all the rest the amount of the drug administered was relatively trivial when compared to the massive doses to which the patient was subjected with perfectly

On the other hand, clinical improvement was by no means proportionate to the amount of the drug administered. In some of the most satisfactory clinical results the dosage was as low as 0.2 milligram daily or every other day, while some of the failures received relatively huge amounts of the drug.

In most instances such untoward symptoms as nausea, bleeding, vertigo, and epigastric distress could be controlled by drastically reducing dosage, and then stepping it up again as the toxic effect disappeared. Bleeding was controlled by discontinuing the drug for about 1 week and then resuming it in a more cautious and more carefully observed program. Bleeding in 2 cases was controlled by the administration of small doses of semandren, a male hormone preparation.

One of the most important points in evaluating the usefulness of a new synthetic estrogen is its capacity to function without the untoward effects of the old. As previously pointed out, one of the greatest drawbacks to the use of diethylstilbestrol has been the comparatively high incidence of so called toxic effects, which have been reported in as many as 80 per cent (12) of the cases treated. In our series we have administered hexestrol to 46 patients who had previously been on diethylstilbestrol. The results of this study are tabulated as follows: nontoxic on hexestrol or stilbestrol, 30 cases; toxic on stilbestrol, nontoxic on hexestrol, 10 cases; toxic on hexestrol, nontoxic on stilbestrol, 2; toxic on both hexestrol and stilbestrol, 1; improvement on stilbestrol, not on hexestrol, none; improvement on hexestrol, not on stilbestrol, 3.

#### SUMMARY AND CONCLUSIONS

1 Our experience of 7 years, with estrogenic therapy in the Gyn-Dysfunction Clinic of the Cincinnati General Hospital is reviewed.

2 A review of the cases of 358 patients treated during this period would indicate that

hexestrol is the most effective of the estrogens we have investigated.

3 Continuous mass dosage of hexestrol appears to result in a lesser incidence of complete failures, while "in phase" administration produces the greater percentage of completely symptom free results.

4 Hexestrol causes a much smaller percentage of "toxic" effects than diethylstilbestrol, but must be administered in from three to five times the dosage of the latter drug to secure the same clinical result.

5 From a consideration of all the data accumulated, it would seem that the best clinical results might be expected from the administration of hexestrol "in phase."

NOTE—The Wm. S. Merrell Company were most helpful in the compilation of these data. They, as well as E. R. Squibb and Company, Ayerst, McKenna and Harrison, The Schering Corporation, Winthrop Chemical Company, and the S. L. Massengill Company, each furnished some of the estrogens used in this study.

#### REFERENCES

- 1 BIEREN, R. E., and COMPTON, C. C. *Am J Obst*, 1942, 44: 287-291.
- 2 BISHOP, P. M. F., BOWES, R. A., BOYCOTT, M., KELLAR, R., MACGREGOR, T. N., and MURLESS, B. C. *Lancet*, Lond., 1940, 1: 620-633.
- 3 CAMPBELL, N. R., DODDS, E. C., and LAWSON, W. *Nature*, 1937, 142: 1121.
- 4 CAMPBELL, N. R., DODDS, E. C., LAWSON, W., and NOBLE, R. L. *Lancet*, Lond., 1939, 2: 312-313.
- 5 DODDS, E. C., and LAWSON, W. *Nature*, 1937, 139: 1068-1069.
- 6 FREED, S. C. *Illinois M J*, 1941, 80: 139-141.
- 7 KAHNT, L. C., and DOISY, E. A. *Endocrinol*, 1928, 12: 760.
- 8 The Wm. S. Merrell Co. Research Laboratories, Cincinnati, Ohio. Personal communications.
- 9 MUCHLE, C. W. *Am J Obst*, 1940, 40: 133-135.
- 10 RUSS, J. D., and COLLINS, C. G. *J Am M Ass*, 1940, 114: 2446-2448.
- 11 SEVRINGHAUS, E. L. *J Am M Ass*, 1940, 114: 685-686.
- 12 SHORR, E., ROBINSON, F. H., and PAPANICOLAOU, G. N. *J Am M Ass*, 1939, 113: 2312-2317.
- 13 SMITH, G. VAN S., and SMITH, O. W. *J Clin Endocr*, 1941, 1: 983.
- 14 SPIEGELMAN, A. R. *Am J M Sc*, 1940, 200: 228-234.
- 15 STURGIS, S. H. *N England J M*, 1942, 228: 371-376.
- 16 TEAGUE, R. S. *J Pharm Exp Ther*, 1942, 75: 145.
- 17 WHITE, P., and HUNT, H. *J Am M Ass*, 1940, 115: 2039.



# HAZARDS CONNECTED WITH THE TREATMENT OF VARICOSE VEINS

LAWRENCE N. ATLAS, M.D. Cleveland, Ohio

WITHIN recent years I have been impressed with the number and variety of mishaps which may occur as the direct result of treatment designed to obliterate varicose veins. These are not complications which supervened because of some basic contraindication to the particular form of therapy employed. On the contrary they must be considered as definite hazards which are indigenous to certain methods or are the result of either improper technique or the failure to observe certain precautions. These untoward incidents do not occur with sufficient frequency to justify the assumption that the management of varicose veins is a hazardous undertaking. However to the physician who has the misfortune of being responsible for a serious complication resulting from the treatment of such an apparently benign condition as varicose veins, the low incidence of that particular complication affords dubious consolation.

The present day management of the majority of cases of varicose veins is based on the resection of the proximal end of the great saphenous vein and the subsequent injection into the varicosities of a sclerosing solution. The operative procedure is popularly known as a ligation, a particularly unfortunate term. It has been repeatedly demonstrated that a simple tying off of the upper end of the saphenous vein is frequently followed by a recurrence of the varicosities at some subsequent date even though all varices are adequately obliterated at the time. (For a particularly excellent discussion of this phase of the subject the reader is referred to an article by Stalker and Heyerdale.) Properly executed, the operation essentially consists of a division of the great saphenous vein at a point just distal to its entrance into the

femoral vein and a resection of its proximal 2 inches. The operator who is not thoroughly acquainted with the numerous variations in the normal and pathological regional anatomy may encounter considerable difficulty.

Although not personally responsible for these two particular accidents, I have had the opportunity of observing cases in which the femoral vein was inadvertently tied or the femoral artery injured. Hemorrhage is not an infrequent occurrence. The saphenous vein and bulb may be enormously dilated and very thin, or in the presence of a long standing varicose phlebitis or ulceration these structures may be brittle and friable and surrounded by inflammatory tissue. Under such circumstances, injury to the vein may be difficult to avoid and the resultant bleeding profuse and hard to control.

## CASE REPORTS

**Cas.** A 56 year old white female gave the history that for 5 years she had suffered from varicose veins and painful ulcers on her foot and leg. The ulcers would intermittently heal and then recur.

Examination revealed large tortuous varicosities along the inner portion of the thigh, leg, ankle, and foot. The Trendelenburg test was singly positive and the Perthes test was negative. The medial aspect of the lower half of the leg was scarred and indurated and presented a large chronically inflamed ulcer.

Resection of the saphenous bulb as advised. The operation as performed under local anesthesia. The upper end of the great saphenous vein as exposed and found to be imbedded in dense inflammatory tissue. It was mobilized with difficulty and divided between ligatures. At this point the operation should have been terminated. However the dissection was carried further and in an attempt to mobilize a large lateral tributary of the saphenous bulb, the branch was torn. Profuse hemorrhage resulted. A clamp placed on the injured vein only increased the size of the tear. Finally the only recourse was to pack the wound. The pack as removed in 3 days and bleeding recurred. The wound was again packed. Three days later the pack was again removed without recurrence of bleeding.

From the Peripheral Vascular Clinic, Division of Surgery, Cleveland City Hospital, and from the Department of Surgery, School of Medicine, Western Reserve University.

However, at this time the patient exhibited evidence of femoral vein occlusion. The leg became edematous and has remained so. The ulcer has increased in size.

The retrograde injection of a sclerosing solution into the distal portion of the divided saphenous vein at the time of operation is a widely accepted procedure. I am acquainted with 5 instances in which this maneuver was followed by a thrombosis of the deep veins of the thigh. Two of these patients died from pulmonary embolism, 1 suffered a pulmonary embolus but recovered, each of the other 2 developed a "milk leg" with permanent disability. As will be demonstrated later, anything injected into the saphenous system of a leg rapidly enters the deep venous system of that extremity. Ordinarily, thrombosis of the deep venous tree does not follow injections of sclerosing solutions into superficial varicosities because the patient is ambulatory, the deep venous tree is widely dilated, and the current of blood is swift, and hence the solution is rapidly diluted and does not have the opportunity to irritate the intima sufficiently to produce thrombosis. As will be demonstrated, there are even exceptions to this rule. However, when an individual is necessarily recumbent for a few hours during and after an operative procedure, the deep venous tree is not widely dilated nor the current of blood as swift. Consequently, any sclerosing solution finding its way into the deep veins has a better opportunity of irritating the intima sufficiently to produce subsequent thrombosis.

CASE 2. A 45 year old white male was seen at the request of his attending surgeon. Three months previously he had had a high resection of his great saphenous vein with retrograde injection of a sclerosing solution down the distal portion of the vein. Three weeks later he was suddenly seized with severe pain in the leg, thigh, and groin. Shortly thereafter the entire leg became swollen up to the groin. He was in bed for 9 weeks. Since resuming activity the same swelling recurs by the end of the day. Examination revealed an edematous lower extremity. The extent and distribution of the edema were characteristic of an iliofemoral thrombosis. He was advised to wear an elastic stocking, to sleep with his leg elevated, and to receive a mercurial diuretic as often as it could be safely given.

CASE 3. A 70 year old white male was seen at the request of his attending surgeon. Five days previously he had had a high resection of his great

saphenous vein with retrograde injection of a sclerosing solution. Within 24 hours the entire length of the varicose saphenous vein became hard, red, and painful. Three days after the operation he was suddenly seized with substernal distress, dyspnea, and a feeling of faintness. At first it was thought that the man had suffered an acute coronary occlusion. However, competent investigation by a consultant established the diagnosis of pulmonary embolism. This patient recovered. This man had a widely dilated and tortuous great saphenous vein which had thrombosed from ankle to groin as the result of a single retrograde injection.

CASE 4. A white male, aged 61 years, entered the peripheral vascular clinic at Cleveland City Hospital complaining of varicose veins of many years' duration. Examination revealed large varices involving the great saphenous system with a singly positive Trendelenburg test and 1 negative Perthes test. A resection of the upper end of the saphenous vein was performed. At the time of operation 2 cubic centimeters of quinine urethane were injected down the distal portion of the divided saphenous vein. Three weeks later he was suddenly seized with severe dyspnea, cyanosis, dizziness, and weakness. He was admitted to the medical service in a state of shock. He was treated vigorously but did not respond and expired within 48 hours.

Autopsy revealed massive embolism of the pulmonary artery with evidence of several additional pulmonary infarctions of recent origin. The external iliac vein on the side operated upon was thrombosed. The thrombus extended down into the femoral vein. *The thrombosed iliofemoral vein exhibited no evidence of inflammation and the thrombus was not attached to the vein wall.* This latter observation is of great importance. It confirms what I have repeatedly observed in cases of postpartum, postoperative, and posttraumatic thrombosis of the deep veins of the leg, that a thrombus may remain in the iliofemoral vein for weeks without exciting an inflammatory reaction in the vein wall that will fix the clot *in situ* and abolish the danger of pulmonary embolism.

To prevent this leakage of sclerosing solution through the communicating veins in the thigh into the deep venous tree it has been suggested (7) that the injection be made through a ureteral catheter which has been passed down the length of the divided saphenous vein. As will be demonstrated, deposition of sclerosing solution distal to the knee does not safeguard against leakage of the solution into the deep veins of the leg with subsequent thrombosis and pulmonary embolism. Besides, the passage of the catheter may injure the vein wall, the fluid leaks into the perivenous tissue, and a massive slough ensues.

**CASE 5.** A 47 year old white female who complained of severe pain in the leg presented the following picture: large varices involving the great saphenous system, a slightly positive Trendelenburg test, negative Perthes test, and a tender area of induration surrounding varix in the medial aspect of the lower third of the leg. A resection of the upper inches of the saphenous vein as performed. A urethral catheter was passed down the divided saphenous vein. An obstruction to the passage of the catheter was encountered about 5 centimeters from the femoral orifice, the catheter was withdrawn, rotated and passed beyond the obstruction without apparent further difficulty. Ten cubic centimeters of hypertonic saline-glucose mixture was injected through the catheter. During the injection she complained of severe pain in the thigh. Unfortunately the pain was interpreted as being due to venospasm and the injection was completed. The following day there was an area of necrosis 4 inches in diameter at the site where the obstruction to the passage of the catheter had been encountered. During the ensuing month this entire area sloughed down to the deep fascia of the thigh. Healing was slow and the patient was left with an unsightly scar.

The injection of sclerosing solution directly into varicose veins in an ambulatory patient may also be followed by unfortunate events, both local and general.

It should be realized that these sclerosing solutions rapidly enter the general circulation where they may in the sensitive individual produce alarming and occasionally fatal reactions. The literature is replete with reports of such untoward incidents. Several years ago one of our clinic patients reacted fatally to an injection of quinine urethane. We have also had several alarming reactions to sodium morrhuate. Similar reactions have been reported to follow the injection of monolate (1, 3).

Locally three complications to the injection of sclerosing solutions are encountered which are of considerable importance. They are ulceration, phlebitis, and thrombosis of the popliteal vein. Ulceration follows the deposition of certain sclerosing solutions outside the vein. Solutions of quinine urethane and hypertonic saline-glucose mixtures are the worst offenders. The accidental perivenous injection of such solutions as sodium morrhuate monolate synasol and aoricin is less prone to produce a slough but may cause painful areas of induration which require a long time to absorb. The obliteration of varices by the injection of sclerosing solutions depends

for its success on the production of a chemical phlebitis. Consequently some pain is to be expected at the time and for a short while subsequent to the injection of a varix, and patients should be warned that the injection treatment of varicose veins is not a particularly pleasant experience. At times, an individual over-reacts to the injection of a varix with a chemical phlebitis of such severity that he is disabled for days or weeks. By far the most serious complication of the injection treatment of varicose veins is thrombosis of the popliteal vein. This extremely serious complication may follow the injection of a varix anywhere distal to the knee and may occur in the simplest type of case. The following case report is illustrative.

**CASE 6.** A 44 year old white female was admitted to the varicose clinic of Cleveland City Hospital with the complaint of painful varicose vein in the left leg. Examination revealed a single moderately sized varix located at the medial aspect of the left calf. Both the Trendelenburg and Perthes tests were negative.

One-half cubic centimeter of 5 per cent sodium morrhuate was injected into the varix as test dose for any sensitivity to the drug. (The injection of small quantity of sclerosing solution as preliminary measure is routinely employed in ruling out sensitivity to the drug.) Three days after the injection she failed the clinic complaining of severe pain in the leg and swelling about the ankle. Examination revealed the varix to be completely thrombosed. The attending surgeon advised her to stay in bed with the leg elevated until the pain and swelling had subsided. She remained in bed for 3 days when she suddenly seized with an attack of subaternal pain, tachycardia, and prostration. She was admitted to the medical service where a diagnosis of pulmonary embolism and an acute cor pulmonale was made. A few days later she experienced another similar attack, and I was asked to see the patient to determine the advisability of ligating the femoral vein.

**Examination.** The popliteal vein could be palpated as a tender thrombosed cord. There was tenderness deep in the calf of the leg and Homans sign (4, 5) was positive. The foot as cold to the touch. There was slight edema about the ankle. The following morning, under local anesthesia, the femoral vein was divided between ligatures just distal to the point of entrance of the profunda. The femoral vein contained no thrombus. Following operation, the patient made an uneventful recovery.

I was particularly disturbed by this case for several reasons. This patient presented

the most simple type of case of varicose veins. There was a single varix limited to a small segment of the great saphenous vein in the middle third of the leg. The negative Trendelenburg test indicated that the valves in the great saphenous vein as well as those in the communicating veins were competent. There was no evidence of a pre-existing deep venous obstruction. Finally, only a very small quantity of sclerosing solution had been used, not in an attempt to thrombose the varix but rather for the purpose of determining sensitivity to the drug. Because of this case and because of the large number of reports of pulmonary embolism following injection of varicose veins which have lately appeared in the literature (2, 6, 9) I was led to investigate what happens to solutions that are injected into the normal great saphenous vein. For this purpose young adults with normal peripheral venous systems were used. Thirty cubic centimeters of 35 per cent diodrast were injected into the great saphenous vein in the lower third of the leg and x-ray pictures taken of the entire length of the lower extremity. Figure 1 depicts what was regularly observed. The radio-opaque solution rapidly found its way into the lesser saphenous vein through anastomoses between the lesser saphenous vein and the injected great saphenous vein. This passage into the lesser saphenous took place in the region of the middle third of the leg. Once in the lesser saphenous vein, the diodrast easily and quickly found its way into the popliteal vein since the lesser saphenous vein joins the popliteal vein behind the knee. The superficial femoral vein is simply the proximal extension of the popliteal vein, hence entrance of fluid into the lesser saphenous vein is practically equivalent to a direct injection into the femoral venous system. Figure 1 illustrates that by far the greatest portion of a quantity of solution injected into the distal major saphenous vein leaves the extremity via the femoral venous system.

#### CONCLUSIONS AND PRECAUTIONS

The obvious inference to be drawn from the preceding discussion is that the modern method of managing varicose veins contains certain inherent risks that can lead to more or



Fig 1 Venogram depicting direction of flow of a radio-opaque solution when injected into a normal great saphenous vein in the lower third of the leg. *N*, Infusion needle in great saphenous vein, *L.S.V.*, lesser saphenous vein, *P.V.*, popliteal vein, *S.F.V.*, superficial femoral vein, *F.V.*, femoral vein, *G.S.V.*, great saphenous vein just distal to point where it passes through fossa ovalis to join femoral vein. Note anastomoses between great and lesser saphenous veins in middle third of leg and that bulk of fluid passes through the lesser saphenous, popliteal, and femoral veins.

less serious complications. Fortunately, by the observation of certain precautions, these accidents can be avoided.

Resection of the upper end of the great saphenous vein, commonly termed high ligation, is definitely not an office procedure. The operation should be performed in an adequately equipped surgery with assistance so that proper exposure of the bulb and all its tributaries is feasible and so that any emergency such as hemorrhage can be managed.

Although many will disagree with me on this point I believe that the retrograde injection of a sclerosing solution at the time of division of the great saphenous vein is hazardous and should be avoided. I would much rather subject the patient to extra injections after he has recovered from operation and be come ambulatory than expose him to the dangers of a possible iliofemoral thrombosis.

Sensitivity to the sclerosing solution used should be determined by a very small preliminary intravenous injection of the drug preferably into the varix to be subsequently thrombosed. A history of hives asthma hay fever and particularly reactions to eating fish indicates the use of hypertonic saline-glucose as the sclerosing agent. When this solution is used the patient should be warned that a severe cramp in the leg will accompany or immediately follow the injection. Quinine urethane is a dangerous solution and its use should be discontinued. Care should be taken to avoid injecting any sclerosing solution outside the vein. I prefer to inject varices with the patient standing. The varix is fully dilated and difficulty in entering is rarely met.

Prevention of leakage of sclerosing solution into the popliteal vein through the lesser saphenous vein is of paramount importance. Before a varix either in the thigh or leg is injected a tourniquet is placed so that it fits into the crease behind the knee. At this point the lesser saphenous vein can be occluded just before it dips into the popliteal space to enter the popliteal vein. The tourniquet is left *in situ* for 5 minutes after the injection has been given. The patient stands during the entire procedure and after the tourniquet is removed he is instructed to walk about so that any solution which might have entered the deep venous system can be rapidly carried away.

#### REFERENCES

1. COHENWELL AND TROMAN, *Southwest M. J.* 949, 44, 408.  
DY AND DUCHING, *J. Am. M. Ass.* 949, 24, 344.
2. GOLDEN, R. F. and HETTERDALE, W. W. *Proc. Mayo Clin.* 949, 5, 25.
3. HOKANA, J. *Am. J. Surg.* 939, 44, 3.
4. Idem, *N. England J. M.* 94, 224, 79.
5. NICH and HARRISON, *J. Am. M. Ass.* 94, 17, 247.
6. PRATT, G. H. *Am. J. Surg.* 939, 44, 3.
7. S. ALLEN, L. K. and HETTERDALE, W. W. *Surg. Gyn. Obst.* 949, 7, 7.
8. V. COHN and LEECH, *J. Am. M. Ass.* 947, 8, 201.

# A STUDY OF DERANGEMENT OF SEMILUNAR CARTILAGES BASED ON 850 CASES

W RUSSELL MacAUSLAND, M D , Boston, Massachusetts

**M**ENISCAL derangements are today well understood in most of their important phases. The causes of derangements, the clinical findings, and the types of injured menisci are well defined. There is general agreement on the treatment of the lesion, and the fact is well established that operative excision of the semilunar cartilage is a highly satisfactory procedure. In adding to the accumulated data on the subject, it is the writer's purpose (1) to present a study of derangements that is based on an experience in this field extending over 30 years, (2) to analyze the findings and end-results in 850 cases that were treated surgically, and (3) to discuss the factors that affect the duration of the convalescent period and the success of operative excision of the cartilage.

## ETIOLOGY

A derangement of the meniscus is usually the result of an injury in which the femur is suddenly twisted inward while a person is bearing his weight on the flexed knee, with the lower leg fixed in the position of external rotation. Participants in sports, and particularly in strenuous sports such as football, basketball, and sking, are exposed to this type of injury, and hence in the younger age group from 18 to 28 the lesion practically always is the result of athletic endeavors. Older people, and especially those with an arthritic background, are likely to twist the knee in minor injuries such as in slipping on a waxed floor or a wet pavement or on the ice. The older person is not unlikely to sustain an injury to the cartilage while at work, particularly if the occupation necessitates holding the knee in a flexed position.

Undoubtedly, a predisposition to the lesion exists if there is any joint laxity. This may be the result of poor musculature, or of the weakening of the ligamentous structure from intermittent effusion in the joint, or of repeated

occupational trauma. Static disturbances such as genu varum and flat feet produce a strain on the knee that makes the cartilage more vulnerable to injury.

Disease of a subacute or chronic nature is sometimes the underlying cause of a meniscal derangement. The lesion may be found in the presence of arthritis or of tuberculosis. In such cases it may be difficult to estimate the degree of the cartilage pathology, and the history and clinical findings as well as the duration of the symptoms must be considered carefully.

In a small percentage of cases the origin of the cartilage lesion is difficult to explain, the patient recalling no injury and the history being negative as to disease. Some authorities have advanced the theory that a degenerative process may be the underlying factor in such cases, and that tears in a cartilage are, in fact, sequelae to such a process. It is highly probable that in such cases there was a minor injury, one so slight as to pass unnoticed, and that the primary tear gradually enlarged until, upon only a slight twist of the joint, the cartilage was displaced.

## AGE AND SEX

Cartilage derangements are most common among men between the ages of 18 and 40 years, which is the period of greatest activity in life. In recent years the ratio of females to males has shown a slight increase, due to women's activity in sports. The lesion is seldom seen in old age or in childhood, although defects of the external cartilage, due to congenital malformation rather than to trauma, are being recognized more frequently in the younger age group.

## PATHOLOGY

*Frequency of involvement of the internal cartilage.* Lesions of the internal cartilage predominate over those of the external, the

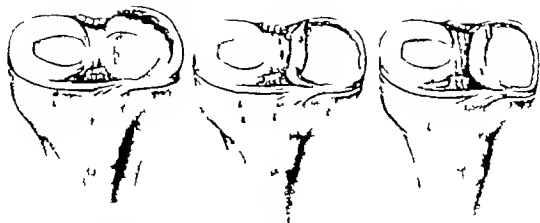


Fig. 1. The cartilage split in trouser like fashion.  
Fig. 2. A bucket-handle fracture of the cartilage

Fig. 3. A variety of bucket handle fracture in which the loop of cartilage is turned over

greater frequency being generally explained on an anatomical basis. The internal meniscus is a less mobile structure than the external, due to its relation to the internal lateral ligament and to its firm adherence to the articular capsule. Hence, in sudden rotation of the thigh the internal meniscus is likely to be jammed between the articular ends and thus torn. The external cartilage on the other hand, having attachments that are more lax, tends to escape the compression force of the articular surfaces, and to slip back into position uninjured following rotation strains of the knee.

*Types of injured cartilages.* The types of injured cartilages that are recognized as characteristic although there is diversity of opinion as to the relative frequency of each type may be classified as follows: fractured or torn cartilages—bucket-handle cartilages; hypermobile cartilages; congenital discoid cartilage.

*A fracture of the cartilage* is a common finding. Any part of the cartilage may be torn. The split may be longitudinal, transverse, oblique or a combination of the longitudinal and the transverse. The longitudinal tear may be complete, running from the anterior to the posterior end of the cartilage or it may be incomplete, splitting the meniscus in a trouser-like fashion (Fig. 1). Another type of

tear is the bucket handle fracture in which the inner loop of the torn cartilage swings into the joint space (Figs. 2, 3, and 4).

The separation of a tag like piece of the cartilage may take place at any part of its periphery. Figure 5 shows the anterior end of the cartilage detached and a tag like flap has been folded back toward the center of the joint.

*The hypermobile cartilage* is not uncommon and must be recognized as a genuine entity. It is the result of abnormal laxity of the meniscus at its periphery from damage to the capsular attachments. Undoubtedly marginal tears are associated more often with the hypermobile cartilage than is usually demonstrated.

*Complicating pathology.* The cartilage in addition to being fractured or loose is commonly found to be thinned or thickened, calcified, frayed, cystic or showing degenerative changes.

Associated lesions are common. Almost without exception the infrapatellar fat pad is found congested and hypertrophied, with little tongue like projections. The crucial ligaments, in particular the anterior ligament are often found considerably engorged, or stretched or even partly torn. Not unusual pathology in the crucial ligaments is a shredding of their attachments. Damage of the

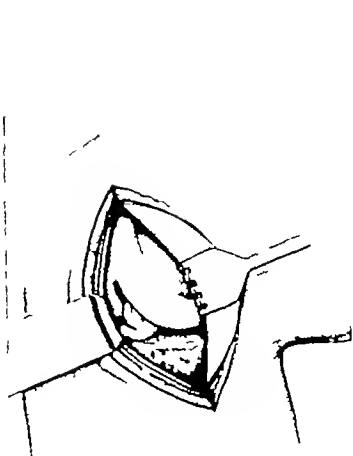


Fig 4

Fig 4. Lateral view of the fracture shown in Figure 3  
Fig 5 Detachment of the anterior end of the cartilage

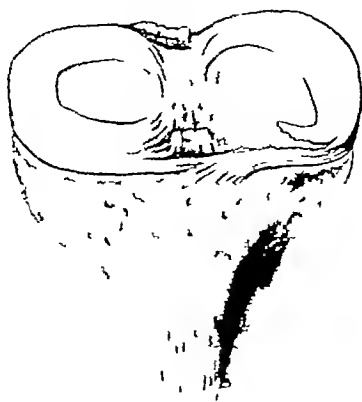


Fig 5



Fig 6

The tab has been folded back toward center of joint  
Fig 6 Line of incision

lateral ligaments, and fractures of the patella, the spine of the tibia, or of the joint surfaces occur in conjunction with a cartilage derangement, but are uncommon. Loose fragments of articular cartilage may be present. There is *always* hypotonia and atrophy of the quadriceps extensor muscle.

In cases of long standing, the synovial membrane is red and swollen, and there may be villous changes in the synovial capsule. The articular cartilage may be covered with a pannus and show eroded areas. Hypertrophic changes may be present in the joint as the result of constant irritation from the damaged cartilage.

*The congenital discoid meniscus.* This type of cartilage represents a lack of normal development. It appears to be peculiar to the external meniscus, although cases of abnormal development of the internal cartilage as well as bilateral malformations have been observed. The form assumed by the cartilage varies widely, in some cases it persists in its fetal shape of a complete disc, and in others it persists as a disc with an open center over which is spread a thin curtain of tissue.

#### SYMPTOMS AND DIAGNOSIS

The patient, who is usually between the ages of 18 and 40, presents a typical history of

injury, at the time of which acute pain was experienced and not infrequently a feeling that the knee gave way. In many cases it was impossible to straighten the knee after the injury, or bending was possible only after someone had pulled on the leg.

Unless the locking of the joint, which causes acute disability, forces the patient to seek medical attention promptly, he experiences several definite attacks of such giving way of the knee before consulting a physician. These attacks vary in severity, but usually they become increasingly mild and clear up more quickly. The patient, however, suffers constantly from the fear that the knee may give way at any time. If the knee remains untreated over an extended period of time, disability increases as the result of repeated damage to the joint in recurrent slippings.

The most dependable diagnostic features are the history of the injury, recurrent attacks of slipping of the knee associated with a feeling of insecurity at all times, intermittent effusion, pain and tenderness in the region of the offending cartilage, atrophy of the quadriceps extensor, and particularly the absence of the cartilage-thrust.<sup>1</sup> Locking of the joint,

<sup>1</sup>The presence or absence of the cartilage thrust may be determined by extending the knee joint. In the normal knee when the joint is extended the cartilage may be felt to hudge or thrust outward between the articular surfaces. This thrust is missing when the cartilage is torn and displaced in the joint space.





*Crucial ligament injuries* The diagnosis of a torn crucial ligament presents no difficulty, and can be distinguished with certainty by the presence of abnormal anteroposterior motion in the knee (a shuck)

*Injury of the internal lateral ligament* Tenderness and pain in these injuries are localized on the medial side of the knee, and they are increased upon abduction of the leg. Lateral movement is abnormally free. The joint is never locked, and other signs of a cartilage derangement, such as the absence of the cartilage-thrust, are lacking.

*Bone injuries* Such injuries as a fracture of the spine of the tibia, or a fracture of the patella without separation, can be differentiated from cartilage lesions by roentgenographic examination. In severe injuries of the knee, however, the meniscus is likely to be damaged, and the symptoms of a derangement appear later following the treatment of the fracture.

#### TREATMENT

*Treatment of derangements of traumatic origin* The treatment of cartilage lesions is based to a certain extent upon an understanding of the repair process in a damaged meniscus. The semilunar cartilages have a limited blood supply, the peripheral zone being vascular, whereas no blood vessels can be traced in the body of the cartilage. True repair of a split or tear may be expected only if the damage lies in the vascular area. Since it is not possible by physical examination to determine the site of the pathology, and because the injured cartilage might be of the simple hypermobile type, primary derangements are given the benefit of conservative treatment for at least several weeks, unless the case is obviously surgical.

*Conservative treatment* The treatment should be carried out promptly. Injuries that appear to be slight should not be neglected. If there is excessive fluid, the joint may be aspirated.

When there is no locking the joint is immobilized in the position of extension. For this means a flannel bandage that extends from the mid thigh to the mid calf or a posterior plaster shell or a hip splint may be used, the type of retentive dressing depending upon the severity of the injury.

If locking with displacement of the cartilage is present, immediate reduction before the repair process sets in is important. There are several effective methods of reduction, among which is that of Jones (16). This method consists of first flexing the knee sharply, then rotating it and moving it sideways to open the joint-space, and finally extending the leg completely. Following the reduction the knee is immobilized in the position of extension as is done in cases in which there is no displacement.

Upon the subsidence of the acute symptoms, which usually takes place within 2 or 3 days, the patient should begin practicing contraction of the quadriceps muscle. Baking, massage, and gentle passive motions are started in a week or 10 days. Walking with the aid of crutches may be started in a few days when the patient is comfortable, the active use being extremely beneficial in easing pain, helping to reduce the swelling, and preventing muscular atrophy.

The period of immobilization varies with the severity of the injury. As a rule, the bandage or splint may be removed in 3 weeks, but if any fluid persists, the joint must be protected longer. No weight should be borne until the fluid has subsided. Any strain on the internal lateral ligament is prevented by raising the inner side of the sole and heel of the shoe, in order to force the patient to walk with the foot in the position of inversion. The patient should make a conscientious effort to improve the tone of the thigh muscles by practicing contraction exercises.

*Operative treatment Indications* A severe derangement of the semilunar cartilage with displacement that proves to be irreducible by manipulation calls for immediate operative interference. Recurrent cases with a history of attacks of slipping followed by pain and tenderness, and unrelieved by conservative treatment, must be treated surgically. The removal of the cartilage should not be postponed in recurrent cases because of the danger of weakening the joint structures through the intermittent effusion, and because of the likelihood of the development of arthritic changes in the presence of defective mechanics of the joint.

When the cartilage derangement is complicated by arthritic changes in the knee the indications for operation must be considered carefully. The age of the patient, the nature of the arthritic process, that is, whether it is local or generalized and whether the disability is due to the cartilage derangement or to the arthritic process are all factors that must be weighed. In the presence of progressing symptoms that are clearly due to a damaged cartilage, prompt operative excision of the meniscus is indicated unless definite contra-indications to any operative interference are present.

*Preoperative care* Even before the operation particular attention should be given to recovering good tonicity of the quadriceps extensor muscle upon which the stability of the knee so largely depends. In the average case of derangement this muscle shows a lack of tonicity within a few days after receipt of the initial injury. The patient while he is waiting to enter the hospital should practice voluntary contractions of the quadriceps, for from 100 to 200 times, every hour that he is awake.

*Operative technique* A careful 2 day preparation of the operative field and rigid aseptic technique are essential to successful arthroscopy. The leg from the ankle to the groin is shaved, then washed with soap and water for as long as 10 minutes, and scrubbed with alcohol and ether. On the eve of the operation, the same field is painted with 3 per cent iodine, the leg held elevated until dry and a sterile dressing applied which is not removed until the time of the operation. Just before the incision is made the area is again painted, this time with 7 per cent iodine.

A tourniquet is applied to provide perfect hemostasis and to prevent postoperative hemorrhage. The knee is properly draped and flexed to the right angle over the edge of the operating table. A sterile towel is laid over the joint, through which the line of incision is imprinted. The towel is then removed.

The routine incision in the case of a derangement of the internal cartilage begins over the upper edge of the femoral condyle and curves downward over the inner border of the tibia (Fig. 6). When the external cartilage is

involved a similar incision is made over the outer condyle. If the symptoms and signs suggest that both cartilages may be involved, or if the injury is so severe that complicating pathology is undoubtedly present, a wider incision that permits the exploration of both cartilages and the entire joint is used. The general use of a wider incision however is unnecessary as is proved by the rare recurrence of symptoms in a large series of cases in which either the smaller internal or external incision was used.

In the case of involvement of the internal cartilage, the operative procedure continues as follows. The surgeon using a fresh knife, incises the fascia, the internal lateral ligament, and the capsule making the incision of sufficient size to expose the cartilage. The damaged meniscus is then removed in its entirety regardless of the amount or the location of the pathology. There may be cases of simple detachment of the anterior extremity of the cartilage with the posterior segment remaining attached in which excision of the damaged portion alone will prove satisfactory but there is always the danger that a tear of the posterior part has been overlooked or that one may occur. In the case of the bucket handle type of fracture the removal of the detached loop alone as recommended by some operators, may prove unsatisfactory because of pathology in the remaining marginal section.

Tension is kept on the cartilage while it is being removed. The anterior part is first freed and then the operator holding this end of the cartilage under tension by means of Ochsner snaps dissects the remaining portion from its attachments. The posterior section is severed by means of scissors so fashioned that they conform to the contour of the tibial tuberosity. In order to make the dissection easier the tibia may be rotated or a blunt dissector may be pried between the articular surfaces. Care must be taken not to damage the articular cartilage in removing the meniscus.

The interior of the joint is then inspected thoroughly and any other pathological condition noted. This step in the operative procedure is of extreme importance. If the articular

lar cartilage is frayed, eroded, or degenerated, it should be trimmed until normal cartilage is encountered. Loose bodies should be removed, and in order to make certain that none are overlooked, the joint should be explored with the gloved finger. A hypertrophied infrapatellar fat pad should be excised. Large bony spurs which are the result of arthritic changes should be removed. The crucial and lateral ligaments should be inspected, although the damage is seldom so severe that repair is necessary.

Attention is now given to closing the wound. The capsule and internal lateral ligament are sutured with interrupted fine catgut. The fascia is closed with continuous catgut No. 2, and the skin with silk. A sterile dressing is applied, extending from the mid thigh to the toes, with the leg held straight. A snugly fitted flannel bandage is finally applied, extending from the mid thigh to the toes, with moderate compression over the knee. Only at this time, when compression has been applied, is the tourniquet removed, thereby preventing any postoperative effusion and oozing into the joint.

*Postoperative care.* Most important in the after-care are the preservation and improvement of the tonicity of the quadriceps extensor muscle. As soon as the patient is comfortable, contractions of the quadriceps should be practiced hourly during the day, from 100 to 200 times. In about a week or 10 days the patient may get up and start walking with the aid of crutches. The compression bandage is worn for from 10 days to 2 weeks, and upon its removal, baking and massage and gentle passive motions are begun. In about 3 weeks the patient should be able to bend his knee to a right angle, and in from 4 to 6 weeks to return to moderate activity.

*Treatment of the congenital discoid cartilage.* A suspected congenital discoid cartilage in the child is left untreated if it causes no discomfort or disability, although in cases of recurrent snapping there is the possibility that arthritic changes may develop. On the other hand, when the patient experiences attacks of pain or is in any way handicapped by the presence of such a cartilage in the knee, operative excision is indicated.

In the treatment of a suspected congenital meniscus with a superimposed injury, the surgeon is guided by the relation of the trauma to the symptoms. In a knee that has had a definite click and in which the symptoms have been aggravated by trauma, operative removal of the cartilage is advisable. In the treatment of patients who have no history of snapping, conservative measures are first adopted.

#### ANALYSIS OF CASES

The series of 850 operative cases to be discussed were treated over the 37 year period from January, 1904, to December, 1941. A review of 388 of these cases, which had been treated in the 25 year period from 1904 to 1930 was published in 1931.<sup>1</sup> Owing to the fact that data are sometimes missing from clinical records, it has not always been possible to report findings in all 850 cases.

*Sex, age, and knee involved.* Of the 850 patients, 541, or 64 per cent, were males. In recent years, the ratio of females to males showed a slight increase, a variance that may be due to women's increasing activity in sports.

The ages were recorded in 786 of the 850 cases. At the time of the operation, 405 cases, or approximately 50 per cent, were between 20 and 40 years of age, the larger number (251) falling into the age group between 20 and 30 years. In the age group between 10 and 20 years, there were 172 cases, and in the group between 40 and 50 years, 107 cases. Only 6 patients were under 10 years of age, and only 27 were over 60.

There was only a slight difference in the number of cases from the standpoint of the knee involved. There were available 820 records, and of this number 428 were derangements of the right knee, and 392 were of the left knee.

*Causes.* By far the majority of young people had injured the cartilage while active in sports, and practically every sport was represented, with football, basketball, and sking holding prominent places. In a large percentage of the older age group, a fall had been the responsible factor, in particular falls on the

<sup>1</sup>Ann Surg 1931 93 649

ice or on wet floors or pavement. In a small proportion of cases the knee had been injured in an automobile accident.

Disease was the underlying factor in 5 cases tuberculosis being the cause in 1 case and hypertrophic arthritis in 4 cases.

In several cases the patients reported that the cartilage had slipped without apparent cause the onset being sudden in some cases and gradual in others.

*Duration of symptoms* The period of time that had transpired between the initial attack and the date of operative intervention ranged from the minimum of a few days in 6 cases to the maximum of over 30 years in 3 cases. By far the majority of patients had experienced recurrent attacks for months or years, and the larger proportion of these had had symptoms for from 1 to 5 years. The time lapse in the 768 cases in which this factor was recorded was as follows: a few days, 6 cases; 1 to 3 weeks, 85 cases; 1 to 10 months, 260 cases; and 1 to 30 years 417 cases.

*Surgical pathology* Lesions of the internal cartilage predominated over those of the external the ratio of injuries of the former to those of the outer meniscus being 6 to 1. Both cartilages in the same joint were involved in 124 cases. No data on this finding were available in 43 cases.

Owing to the fact that more attention has been given to recording the exact pathology in recent years, the data on the type of damaged cartilage and the nature of the associated pathology are more complete in the later series of cases than in that published in 1931. In the earlier series of cases (435 cartilages) the hypermobile cartilage held a prominent place 146 or 34 per cent of the damaged cartilages being recognized as of this type. Undoubtedly fractures existed in many of these cases but they were overlooked or were not mentioned in the records. Tears were found to be present in 149 cases, but the site and type of fracture were noted in only a few instances.

In the later series of 462 cases (539 cartilages) fractures were demonstrated in 303 instances. The greater number were located in the posterior part of the cartilage and the next most frequent site of involvement was

the anterior end. Splitting of the cartilage in trouser like fashion and tears running the entire length of the cartilage from its anterior to posterior end were common. The bucket-handle fracture was present in 47 cases. The hypermobile type of cartilage was found in 158 of the 539 cases. There were 4 cases of a congenital discoid meniscus. Six cartilages were cystic 1 was calcified 1 was missing entirely and 32 were thinned or thickened. In 34 cases the pathological process was not recorded.

Lesions of other joint structures were associated with the damaged cartilage in many instances. In the later series of 462 cases, the most common complications were arthritic changes 56 cases damage of the crucial ligaments 51 cases erosion of the articular cartilage 13 cases and loose bodies of bone or cartilage 24 cases. Less frequent concomitant lesions were fractures of the patella, 1 case fractures of the spine of the tibia, 7 cases fractures of the tibial tuberosities, 9 cases and fractures of the femoral condyles, 5 cases.

*End results* Questionnaires were sent to 842 of the 850 patients. Inquires were not sent to the other 8 patients because of the fact that the presence of serious complications at the time of the operation would preclude judging the outcome of the surgical procedure. In this group were the following: 1 case of postoperative sepsis 1 tuberculous knee 1 Charcot joint 3 cases of generalized arthritis 1 severe fracture and 1 case of intermittent hydrops.

The patients were questioned on the following points: (1) their satisfaction with the operation (2) the amount of motion in the knee (3) the stability of the knee (4) the comparative strength of the two knees, and (5) the time lapse before activity was resumed after the operation.

Replies were received from 656 patients. In these cases the time interval between the operation and the postoperative check was as follows: 5 to 10 months, 9 cases; 1 to 10 years, 511 cases; and 10 to 25 years, 136 cases.

Five hundred and forty of the 656 patients who returned the questionnaires expressed satisfaction with the outcome of the operation. All of the patients had resumed their normal

life and returned to their regular occupations including nursing, trucking, teaching, dancing, carpentry, and the heavy industries. Twenty-seven patients were in the Army, 6 in the Navy, and 4 in the Air Corps. Many engaged in strenuous sports. The majority of the "satisfied" group had resumed activity in 3 months after the operation.

Approximately half of the group claimed some slight disability or discomfort, although they were able to continue their work and participate in sports. Most serious was a slight limitation in motion, especially in flexion, in 142 cases. Several patients (78) experienced a feeling of instability at times, as after considerable walking or exercise, or in running, or in going up or down stairs. Several (149 patients) reported that the knee operated upon was weaker than the normal joint so that they tended to favor it. Thirteen patients complained of pain in damp or stormy weather. In this group of cases, factors such as the complication of arthritis or damage of the crucial ligaments, or the question of litigation, must be considered in weighing the patient's opinion as to the outcome of the operative excision of the cartilage.

Forty-nine patients replied that they were only partly satisfied with the result. Some complained of a limitation of motion, weakness, and instability, others experienced only a sense of weakness, and still others claimed a recurrence of the symptoms of a deranged cartilage. These patients were asked to report for an examination of their knees. In only 7 of the 49 cases could the results be considered unsatisfactory from the surgeon's standpoint. In 8 cases the cartilage had been removed in the presence of coexisting arthritis, and several of these patients had suffered from a slipping cartilage for years before the operation. In 3 cases there had been damage of the crucial ligaments. Seven patients had a persistent weakness of the quadriceps muscle. One patient had had a fractured hip on the same side as the deranged cartilage, 1 had sustained a new injury and damaged the other cartilage, 1 had had an ulceration, but healing was satisfactory, and in 1 case there had been an inflammatory reaction in the synovial sac that precluded a good outcome from the cartilage

# SUMMARY OF 850 CASES—541 MALES, 309 FEMALES

Age—years	Number
4 to 10	6
10 to 20	172
20 to 30	251
30 to 40	154
40 to 50	107
50 to 60	69
60 to 75	27
Unrecorded	64
Knee involved	
Right	428
Left	392
Unrecorded	30
Duration of symptoms before operation—	
Days	6
Weeks—1 to 3	85
Months—1 to 10	260
Years—1 to 30	417
Unrecorded	82
Cartilage involved—	
Internal	591
External	92
Both	124
Unrecorded	43
Pathology—	
Early series, 435 cartilages	
Hypermobile	146
Fractures	149
Dislocations	50
Totally avulsed	5
Unrecorded	85
Later series, 539 cartilages	
Fractures	303
Hypermobile	158
Congenital discoid	4
Unusual pathology	40
Unrecorded	34
End results—842 questionnaires	
From patient's standpoint—	
Good	540
Partly satisfactory	49
Unsatisfactory	67
No replies	186
From surgeon's standpoint—	
Good	614
Partly satisfactory	7
Poor	26
Satisfactory in 186 "no reply" group	32
Unclassified	13
No replies	150

operation. Four patients were seeking additional compensation from insurance companies. In the 16 remaining cases there appears to be no explanation of the patient's unfavorable opinion, as several of the patients were active in such sports as skiing and soccer,

1 was a foreman and stood on his feet for 12 hours a day 1 patient aged 50 years had only the complaint that he could not squat and a boy claimed that he had symptoms, but his mother wrote that the knee was perfectly satisfactory

Sixty seven patients were definitely dissatisfied with the outcome of the operation Upon investigation of these cases It was found that from the surgeon's standpoint only 25 were poor results. Eighteen patients claimed a recurrence of the slipping of the knee and although several of them refused to report for examination it must be assumed that pathology in the form of a derangement of the other cartilage a loose fringe or an enlarged infrapatellar fat pad was present One knee became septic. Two patients complained of constant pain 1 had an unstable knee 1 a stiff knee and 1 experienced instability and pain In 1 knee there was a beginning dissection.

The results in 10 cases could not be classified Two patients had injured the knee shortly after the operation 1 had a blood stream infection 1 a Venereal infection 1 a tuberculous knee There was an osteochondritis in 1 knee. Two knees had been so severely injured that it was impossible to judge the outcome of the excision of the cartilage One patient left the hospital against advice and 1 patient consulted an osteopath.

In the remaining 32 of the 67 cases, the result of the operation itself was satisfactory the symptoms of the deranged cartilage being relieved and the joint generally improved. In these cases the presence of such complicating factors as arthritis crucial damage and persistent weakness of the quadriceps were responsible for the condemnation of the operation

In the group of 86 patients from whom no replies were received an attempt was made to judge the result from the patient's record and in 36 cases examinations had been made after a sufficient time to permit classifying the outcome There were 32 good results in this group 4 of which were complicated by an arthritis and 1 by weakness of the quadriceps muscle Three cases could not be classified because of the severity of the initial injury in

1 case and because of a nervous element in 2 cases. One knee became septic.

*Summary of end results* In this series of 890 cases conclusions on the end results are based on 692 cases, including the 656 replies received from questionnaires that were sent to the patients, and 36 cases on which it was possible to judge the outcome from the clinical records. Whereas only 540 patients expressed complete satisfaction with the outcome of the operation, a careful investigation of these cases showed that 646 or 90 per cent, obtained good results from a clinical standpoint In 7 cases results were partly satisfactory In 26 they were poor and 13 results could not be classified

#### PROGNOSIS AND FACTORS AFFECTING OPERATIVE RESULTS

From the standpoint of both the patient and the surgeon the operation for excision of a deranged meniscus is a highly successful procedure The average patient, if treated promptly upon the recognition of the lesion, obtains a knee that is stable painless, and has complete function The patient is usually able to return to office work within a few weeks and to strenuous occupations in from 2 to 3 months.

Unsatisfactory results following the operative removal of the cartilage as well as a prolonged convalescence may be traced either to one of several factors or to a combination of factors.

*Arthritic changes* The prognosis is not so favorable and a longer convalescence may be expected in patients in whom an arthritic process or hypertrophic changes are present in the joint at the time of operative intervention. It is well to make the patient acquainted with this fact before the operation is undertaken. In elderly patients these changes may be of a chronic nature involving several joints, and the cartilage may in fact be damaged by the compression of a flat, eburnated condyle Arthritic changes may also be present in the knee of the young adult as well as in the joints of older patients, when the cartilage derangement has been of long standing Such changes are provoked by the repeated trauma to which the knee is subjected and also by

the presence of defective mechanics in the joint

Arthrotomy in cases complicated by arthritic changes may give relief from the symptoms directly traceable to the cartilage derangement, and some functional improvement may be obtained as well as the prevention of further arthritic changes. A less satisfactory outcome must be expected, however, as the removal of the cartilage in no way affects the arthritic changes which are already present, and the knee must always be protected and favored.

*Persistent traumatic synovitis and relaxed ligaments* Repeated trauma with effusion may lead to chronic synovitis and a weakening of the ligamentous structure of the knee-joint, complications that may be responsible for a persistent weakness following the removal of the meniscus. Such a complication may be avoided by early operative interference and by improving the tonicity of the quadriceps muscle through the practice of regular contraction exercises.

*Associated pathology* Injuries of the cartilage are often complicated by damage of other joint structures, which affects the ultimate result of operative excision of the cartilage. A not uncommon lesion is damage of the crucial ligaments, which may give rise to a persistent laxity of the joint following the removal of the cartilage. In such cases, the best treatment consists of measures to improve the muscular structure.

Erosion of the articular cartilage is another common finding at the time of operation, which may prevent obtaining a perfectly satisfactory joint, although the symptoms from the cartilage derangement are eliminated.

Finally, in the presence of such severe injuries as fractures, it is to be expected that the knee in certain cases cannot be restored to normal.

*Weakness of the quadriceps extensor muscle* A most important factor affecting the outcome of a meniscus operation as well as the duration of the convalescence is a persistent weakness of the quadriceps muscle. In such cases, the patients complain that the knee operated upon is slightly weaker or less stable than the normal knee, or that it tires more

easily, or gives trouble in going up and down stairs, in running, or in exercising. The symptoms may be present in cases that have been treated either soon after the initial injury or following recurrences of slipping of the cartilage.

This lack of tone in the quadriceps which accompanies injuries of the knee joint is not due to disuse entirely, because it develops in some cases within a few days after the initial trauma. The more prolonged the symptoms of a derangement, the more severe are the hypotonia and atrophy of the muscle, and in such cases a long period of time may be required to restore the normal tone.

In view of the extreme importance of the tonicity of the quadriceps extensor to the stability and function of the knee, particular care should be taken to maintain its tone throughout the course of treatment. It should be particularly impressed on the patient that he must co-operate fully in order to recover this muscle power.

#### CONCLUSIONS

A study of derangement of the semilunar cartilages is presented, which is based on an experience in this field that extends over more than 30 years. An analysis of the findings in a series of 850 cases is reported. Examination of the end-results in this series of cases showed that 90 per cent of the patients obtained satisfactory results from a clinical standpoint.

The factors that may interfere with obtaining a good outcome by operative intervention are discussed, among which are the presence of arthritic changes or associated pathology in the joint, and the persistent weakness of the quadriceps extensor. Emphasis is placed on the importance of prompt and effective treatment of cartilage derangements in order to prevent the development of arthritic changes, and to preserve and develop the tonicity of the quadriceps muscle.

#### REFERENCES<sup>1</sup>

- 1 BOEHLER, L. *Wien klin Wschr*, 1938, 51, 972
- 2 BRISTOW, W. R. *Am J Surg*, 1939, 43, 458
- 3 *Idem*. *J Bone Surg*, 1935, 17, 605
- 4 BÜCKLE DE LA CAMP, H. *Zbl. Chir*, 1939, 66, 1555

<sup>1</sup>Contributions published on cartilage derangements between the years 1930 and 1942 found to be of special interest are listed.



5. CAYE, L. F. and STAMPER, O. S. *Am. J. Surg.* 94  
54 37
6. CHADLER, F. A. *Surg. Clin. N. America*, 1937 17  
117.
7. CHAFFIN, E. K., and MacKENROY D. G. *J. Am. M.  
Ass.*, 94 7 695
8. DARRACH, W. *Ann. Surg.* 1935. 61 20
9. DICKSON, F. D. *J. Am. M. Ass.* 1935. 2.  
1800000 L. K., and THOMPSON, W. K. *Ann. Surg.*  
1940. 484
1. FERRIS, A. G. T. *Brit. M. J.* 1930. 3. 47. 196.
2. *Ibid.*, 1936. 688.
3. *Ibid.* *Lancet*, Lond. 1936. 35
14. HENDERSON, M. S. *Am. J. Surg.* 1940. 45 513
5. *Idem.* *Proc. Mayo Clin.*, 1934. 9 65.
6. JONES, R. *Ann. Surg.* 1909. 50 909
7. *J. Bone Surg.*, 1911 14 220
18. KRECHWITZ, P. H. *Surg. Clin. N. America*, 1931. 17  
1 5.
9. MEADE, F. J. *Internat. Coll. Surgeons*, 1942. 5 43
20. MAYER, L. et al. *Am. J. Surg.* 1930. 43 301.
1. MITCHELL, D. S. *Brit. J. Surg.* 1936. 24 264
2. MORRIS, C. R. *Am. J. Surg.* 1912. 55 26
1. NICHOL, L. *Rev. med. Suisse rom.* 1940. 60 74
24. OBER, F. R. *Surgery* 1930. 6 24
5. PRINZ, H. *Beitr. klin. Chir.* 1937 45 137

# ROENTGEN PELVIMETRY

## A Commentary

HERBERT THOMAS, M.D., New Haven, Connecticut

THE perfection of all technical techniques to furnish definite information concerning pelvic capacity has depended almost exclusively the reliability of ordinary external pelvic measurements. So far as obstetrics is concerned, the latter methods can give little general idea of available pelvic space and experience has shown that it furnishes information which may be exceedingly faulty. It is obvious that if the knowledge of pelvic dimensions and pelvic conformation is a vital and absolute prerequisite to successful obstetric practice, as complete as necessary and of reasonable accuracy. It can hardly be questioned that such knowledge is useful for a greater part of the problems associated with labor, in the nature of a mechanical art, and as Konyak has stated: "The obstetrician like the engineer must understand his tools in accordance with the principle which make a given mechanical problem safe or unsafe, possible or impossible." However it must not be forgotten that in civil as in this knowledge of pelvic dimension and pelvic conformation, the bony pelvis and its bony important part of the rather complicated labor mechanism and bearing this in mind the statement of Dippel regarding roentgen pelvimetry is of particular interest. He writes: "It may be argued that there are so many factors in labor, namely the size of the baby and the character of the uterine contractions that an approximation is enough. We do not agree with this viewpoint. The fact that the other factors are difficult to evaluate accurately makes it all the more important in cases of contracted pelvis, that we should have as precise information as possible concerning the one factor we can measure with precision."

Because of the definite clinical significance of variations in the bony pelvis the experience

of the writer has led him to go beyond this and to recommend that all primigravida women should have the benefit of the roentgen survey of the pelvis. During the past 7 years this has been done in our clinic and nearly 1000 patients have been so surveyed. The results have been convincing for not only have I discovered numerous unsuspected pelvic anomalies but clinically significant pelvic variations have been noted that otherwise would have remained undetected. In this connection the statement of an eminent British obstetrician is pertinent. In 1930 F. M. Murray Kerr wrote: "I do not think that with the knowledge now at hand regarding the influence exerted even by minor variations of pelvic conformation, we should advocate routine pelvic radiography for all primigravidae have lost our sense of proportion in the matter as many suggest today. On the contrary, I make bold to predict that before many years pass it will be accepted as an essential detail of the antenatal examination."

The chief purpose of the present communication is to comment generally upon this subject drawing upon an experience now extending over two decades and hoping that these observations will be helpful to those who are interested in the practical application of roentgenometry to clinical obstetrics.

1. By the term 'roentgen pelvimetry' we include a roentgen visualization of the pelvis in which not only pelvic measurements may be made but important pelvic contours may be studied.

2. Any method of roentgen pelvimetry to be generally useful must be simple, accurate, inexpensive, and capable of ready interpretation by those engaged in the practice of obstetrics.

3. Roentgen pelvimetry should be done during pregnancy and the results incorporated in the prenatal record. In this way will be accumulated a store of information which will

From the Department of Obstetrics and Gynecology, Yale University School of Medicine.

enable us further to evaluate the clinical significance of pelvic variations and to establish average dimensions in certain groups. Apparently the largest number yet reported from this point of view is the author's study of 100 white women published in 1931. In cases at term or in labor in whom disproportion is present or suspected further roentgen studies should be carried out, but roentgen pelvimetry as here defined should be a pre-natal procedure.

4. It should be emphasized that the responsibility for interpreting roentgen films belongs definitely to the obstetrician. However it requires experience to evaluate these findings, for we must recognize the fact that previous to the use of roentgen techniques our knowledge of the bony pelvis in the living being was largely rudimentary. The obstetrician in interpreting roentgen films must possess a knowledge of the newer concepts of the pelvis from the obstetrical viewpoint. This can best be obtained from the ever growing literature on this subject. The actual measurement and visualization of the pelvis with the techniques that we employ is almost as simple as viewing the dried anatomical specimen.

5. A more general adaptation of roentgen pelvimetry to clinical obstetrics has been somewhat delayed by the multiplicity of roentgen techniques that have been developed. This has come about because many investigators have endeavored to seek a degree of accuracy all out of proportion to that which is essential for clinical use. If one considers the entire obstetric pelvis, bones, soft parts, articulations, and the influence of pregnancy upon the latter it is evident that any dimension of the bony pelvic canal which is accurate to 0.5 centimeter must be clinically satisfactory. In the simple methods which we have so long used with a target film distance of 36 inches we are certain that any dimensional error is well under this figure.

6. The two pelvic views which we use in the routine survey are the inlet and lateral views. The use of the 36 inch target film distance is an important point for distortion is minimized at this distance and by using the same distance for each view one can be readily com-

pared with the other and certain dimensions thereby checked in each film.

7. The success of these simple techniques greatly depends upon the proper positioning of the patient. This is not difficult but the roentgen technician must develop a certain amount of skill for good results. At this time it is not proposed to go into the technical details of these procedures, for they have been published fully elsewhere (4) however a short description may be useful in this place. The inlet view (Fig. 1) is taken with the patient semirecumbent using a back rest and centering the target 6 centimeters posterior to the upper symphyseal border. We endeavor to make the pelvic inlet parallel to the film, and this may be accomplished by measuring vertically the distance from the table top to a point 15 centimeters below the upper symphyseal border on its anterior surface and measuring vertically the distance from the table top to the interspace posteriorly between the 4th and 5th lumbar vertebrae. The patient's position must be such that these two points are equidistant from the table top, for they establish the level of the pelvic inlet. (Some observers have suggested that the sides of the inlet or iliopectineal lines in some cases may rest below this level and thus give an erroneous reading of the transverse diameter. Experiments with the dried pelvis and the 36 inch distance have shown us that such error is unlikely and is minimal if present at all.) The lateral view (Fig. 2) is taken with patient standing in the lateral position the target being centered at the upper edge of the acetabulum. The correction of distortion in both views is made with an isometric rule introduced in the plane to be measured and thus appearing on the film. In the inlet view this is done by a double exposure and in the lateral view this scale is projected at the one exposure. A correction table depicting values for various levels for 36 inch target film distance has been used by some investigators and there is no reason why it cannot be successfully used instead of this scale. However having the correction directly on the film makes for simplicity in film interpretation.

8. In viewing the films there are certain portions of the pelvis which have particular

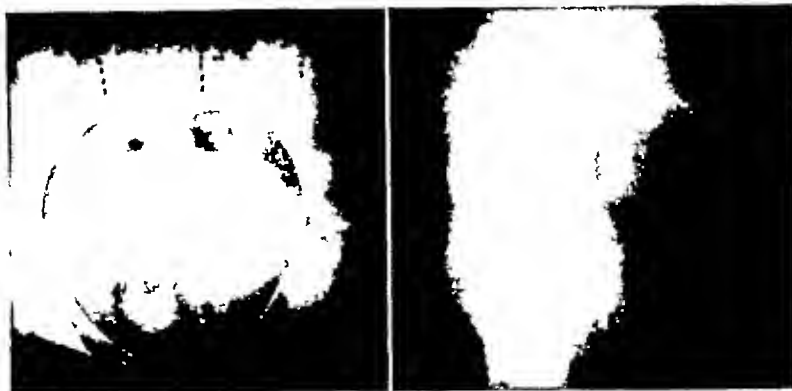


Fig 1, left Pelvic inlet roentgenogram. The top row of dots represents "corrected" centimeters for the level of the pelvic inlet. Interspinous and other lower level diameters are measured by using other series of dots which are calibrated for 5, 6, 7, 8, 9 centimeter levels below that of the inlet.

Fig 2 Lateral pelvic roentgenogram. "Corrected" centimeter scale shown on one side of film. All anteroposterior pelvic diameters may be measured.

obstetrical significance. These are the planes of the pelvic inlet, midpelvis, and pelvic outlet. Any or all of these planes may show abnormal narrowing in one or more diameters. There are also certain contours of the pelvis which have obstetrical importance and a proper pelvic survey cannot be carried out unless both dimensional data and contour study are evaluated.

9 A word might be said concerning the time and expense involved in the making of these two roentgen views. We have found that an allowance for each patient of 15 to 20 minutes is sufficient. As these patients are ambulatory, appointments are made to suit the convenience of the Roentgen Department. The inlet view may be taken on an 8 by 10 film and the lateral on an 11 by 14. The complete cost is well within the range of ward patients to pay and is certainly at a cost-level in line with most clinical laboratory procedures.

10 We do not include pelvic outlet views in the roentgen survey. Roentgen methods are not too satisfactory for accurate mensuration in this portion of the pelvis and the usual palpatory methods are adequate for both mensuration and for determining the important contours. The chief dimension of clinical value is the transverse diameter of the outlet. This is taken at a level 5 centimeters below the inferior border of the symphysis. Because of a lack of definite end points when

using a level lower than this, observers measuring this diameter rarely get consistent results. When we consider the course of the pelvic axis at the outlet and the fact that the suboccipitobregmatic diameter of the fetal head is approximately 10 centimeters, the use of a dimension level at 5 centimeters or the radius of the suboccipitobregmatic circumference seems a more rational and accurate procedure.

11 A brief word may be said concerning the influence of routine roentgen pelvimetry on obstetric procedure in general. Certain facts have become apparent in our comparatively extensive experience. Briefly these are (a) The incidence of trial labor, a procedure which is subject to great abuse, has been lessened, (b) the incidence of the difficult forceps operation has also decreased, (c) the fetal mortality in primigravidae with breech presentation has definitely lessened, (d) it does not appear that routine roentgen studies tend to radicalism.

In 1100 primigravid white women consecutively delivered at term (child 2500 grams or over) our figures for major operative procedures are cesarean section, 26 times or 2.3 per cent, version and extraction 5 times or 0.4 per cent, and midforceps 39 times or 3.5 per cent. Put in another way, 93.8 per cent of this group of primiparous women were delivered without resorting to any major op-

erative procedure. It should be obvious that a number of the above operations were done for indications other than cephalopelvic disproportion. In one group of patients it is certain that the roentgen survey has definitely decreased the incidence of cesarean section and that is in those cases of unengaged head in primigravid women at term, or even in early labor where palpatory methods may have suggested apparent disproportion. In many of these cases roentgen pelvimetry has demonstrated ample pelvic space and shown that a conservative course could be safely followed.

12. In conclusion we must agree that with the rapid increase in the incidence of hospitalization of obstetrical cases have come greater

opportunities for the safe and scientific conduct of labor. In our experience the forehand knowledge of available pelvic space and of pelvic conformation as shown by prenatal roentgen pelvimetry has eliminated certain trial and error methods of obstetric procedure and placed operative measures on a sounder basis. The proper conduct of labor must always be carried out with the least possible trauma to both mother and child, and the roentgen survey of the pelvis is one of the measures which will greatly aid in realizing this desideratum.

#### REFERENCES

1. DOWELL, A. L. *Surg. Gyn. Obst.* 93, 69, 641
2. K. M., *J. M. M. Brit. M. J.* 930, 857
3. RIMMER, A. *J. Med. J. & Rec.*, 930, 3, 470
4. THOMAS, H. *Am. J. Obst.* 941, 4, 957

## AORTIC EMBOLIC COMA

GORDON MURRAY, M.D., F.R.C.S. (Ed.), F.R.C.S. (Can.), Toronto, Canada

WHILE there is doubt if some peripheral arterial embolisms may should be operated upon because of the tenacity for collateral circulation to be adequate, there is no doubt but that complete obstruction of the lumen of the aorta from acute embolism should be operated upon. In a large proportion of these cases the immediate symptoms and signs suggest complete obstruction but under observation for a few hours the findings change indicating that what was originally impaction of the lumen of the aorta has changed by the mass or masses becoming and slipping down one or both sides to a lower level. In these cases however in which the evidence of aortic embolism persists for a few hours the general condition of the patient warrants surgical removal should be attempted otherwise the prognosis is fatal with the result that in nearly all cases the patients go through the painful stages of developing gangrene of both legs and death from toxemia.

The descriptions in the literature (1-6) and comments by surgeons seem to throw an atmosphere of awe and despair about such a condition. On the other hand the technical procedure of removing such an aortic embolus is not difficult and if undertaken within 12 to 20 hours after the accident and successfully completed results are exceedingly gratifying and the prognosis is changed to one of optimism provided the pre-existing cardiovascular disease has not in itself jeopardized the chances of the patient.

A report of 5 successful aortic embolotomies follows. In all 5 cases there were no technical difficulties and no accidents or disasters. The circulation was restored in all 5 cases and the impending gangrene of both legs in each case was immediately replaced by extremities with normal circulation and function thus transforming the picture to that of the original healthy state.

### OPERATION

Several methods of approach have been studied and tried but the one used in these 5 cases which has been entirely satisfactory has been through an extraperitoneal abdominal approach. The incision is a right paramedian extending from 2 inches above the umbilicus to the symphysis pubis. The transversus abdominis is divided and care is taken not to open the peritoneum. An incision plane between the peritoneum and transversus abdominis is easily followed by blunt dissection with the fingers and within a very short space of time the peritoneum is swept out of the right iliac fossa and retracted with the cecum and other intraperitoneal organs to the left side. Only two obstacles to this dissection are encountered. The first is the structure leaving the abdomen through the internal abdominal ring. In the male it is wise to dissect off the vas deferens and spermatic vessels from the peritoneum and leave them behind as the peritoneum is swept to the left side. In the female the round ligament is divided between ligatures. The ureter is the second organ to be protected. It must be reflected off the peritoneum as the latter is elevated and the ureter is left in its original position. When this has been accomplished the external internal, and common iliac vessels on the right side as well as the hollow of the sacrum are well exposed. The chief difficulty in the exposure is the separation of the peritoneum from the posterior rectus sheath and transversus abdominis fascia above the level of the semilunar fold of Douglas and this difficulty is increased above the level of the umbilicus. Over the creases the peritoneum may be opened during dissection. However this matters very little because with the retraction to the left the intraperitoneal contents do not escape and are not in the way during the operation. As the peritoneum is dissected off these areas, the posterior rectus sheath above the semilunar fold of Douglas is divided to the level of the upper end of the skin incision. The dissection of the perito-

From the Department of Surgery, University of Toronto and the Toronto General Hospital.



Fig. Field showing retraction of peritoneum exposing: *a*, bifurcation of aorta, *b*, right common iliac artery, *c*, left common iliac artery, *d*, right ureter retracted over to left side of field, *e*, left ureter crossing lower end of left common iliac artery. Insert showing abdominal incision for approach to aorta.

neum to this point can be carried out within a very few minutes. When proper packing and suitable retraction are applied to this reflected peritoneum the lower 3 inches of the abdominal aorta, its bifurcation, the left common, internal, and upper few inches of the external iliac arteries and veins as well as all those on the right side are exposed in the field.

At this stage the level at which the pulsations disappear in the aorta and the absence of pulsations in the common and other iliac vessels will be obvious. As well the firm masses obstructing the vessels can be palpated with the finger.

The next move is to discover the lower limits of the obstructing embolus in both right and left external iliac vessels. When this has been defined the areolar tissue around the vessels is separated so that a bulldog clamp can be applied distal to the mass on both right and left sides. The distal limits of the masses in both right and left internal iliac vessels may also be defined and similar clamps applied here. This protects the circulation peripheral to this point from smaller masses escaping during future manipulations. The next step is to define the circumference of the abdominal aorta about 1 1/2 to 2 inches above the bifurcation, at which point a length of surgical tape is passed around the aorta in the form of a loop.

By twisting this tape gently and at the same time holding the gently twisted tape with the three inner fingers and by counter pressure with the index finger over the small remaining loop the lumen of the aorta can be gently occluded temporarily. Great care must be exercised in handling this tape because the aorta is friable. A strong tug or jerk on this tape might do irreparable damage in the form of an immediate tear or by damaging the intima, might precipitate thrombosis at a later date.

When the aorta is controlled by a competent and well instructed assistant the stage is set for removal of the embolus. The best plan, in these cases, is to select the most accessible spot on the anterior surface of the right common iliac artery. The adventitia is dissected off the anterior surface of the vessel over an area about 1 inch in diameter so that this structure will not interfere with the repair of the incision in the artery after the embolus has been removed. Through this area an incision 1 1/2 to 2 centimeters in length is made. In most cases firm masses of thrombus or blood clot are encountered immediately. These begin to bulge through the incision. By the gentle compression of the vessel against the wall of the pelvis both above and below this incision the clots are gently extruded. Those on the left side are swept through the left

common iliac vessel across the bifurcation of the aorta and downward to be extruded through the opening on the right side. When, on repetition of these maneuvers, no further clots are extruded and no other abnormalities can be left, the bulldog clamps are released for a few seconds and then reapplied, first on one external iliac artery and then on the other, then on each internal iliac artery. During each of these maneuvers, there should be active bleeding through the incision and, if the patient's blood pressure is good, the bleeding may show moderate pulsation, provided the circulation has been completely cleared of clots in all these directions. If these four points have shown satisfactory return-bleeding, the prospects are that a complete removal of obstructing masses had been accomplished. If such should be the case, a bulldog clamp is then applied to the left common iliac artery, near the bifurcation of the aorta and to the right common iliac 1 inch distal to the incision. When these have been adjusted nicely, the assistant controlling the aorta is directed to relax the pressure of the index finger on the aorta, momentarily. Occasionally further masses of clots are swept out through the incision with the force of the aortic blood pressure. If no further masses are present, free violent pulsating bleeding will occur. The squirt of blood from the incision should reach at least 6 feet from the operative field and in some cases it may fly as far as 15 feet. This is of considerable significance, indicating the freedom of the vessels, to this level, from further clots. An oozing or feeble bleeding from the incision indicates that further clots are present and must be removed.

When by these tests it is proved that the circulation is cleared of clots, bulldog clamps are applied above and below the incision in the artery and 500 units of heparin in saline solution are placed in the lumen of the vessel through the open incision (3). With silk on a fine needle, the incision is then closed with a continuous suture. If the stitches are placed not more than  $1/16$  of an inch apart, there is usually no leaking whatever from the field. When the suturing has been completed, the bulldog clamps distal to the repair are removed first. At this time it is good practice to inject,



Fig 2 Same field as shown in Figure 1. Arrow points to incision in right common iliac artery *b* through which the dark colored thrombus is being extruded.

obliquely through the wall of the right common iliac artery, about 800 more units of heparin in saline solution. Following this the aorta is released and the circulation returns through the vessels of the pelvis. If the operation has been satisfactory, normal distention and pulsation of all the vessels in the pelvis is obvious and, if there are no remaining masses in the circulation, observers at the feet can usually feel pulsation of the vessels at both ankles. The feet and legs change from a mottled cyanotic (5) or marble white hue, to a rosy pink color and the coldness is changed to one of warmth. If everything is satisfactory, the peritoneum is allowed to fall back and is sutured in the right iliac fossa. Any opening in the peritoneum in the region of the umbilicus is repaired and the abdominal wall is closed in layers without drainage.

If the operation has been completed satisfactorily, the results are most gratifying, the appearance of the shrunken extremities is changed from the pallor and cyanosis of impending gangrene to that of a normal rosy pink. The patient is returned to the ward, when continuous intravenous heparin is given in sufficient quantity to keep the blood clotting time at about 15 minutes for the following 3 days.

I L. This patient, aged 19 years, had a history of chronic rheumatic myocarditis, mitral stenosis, aortic



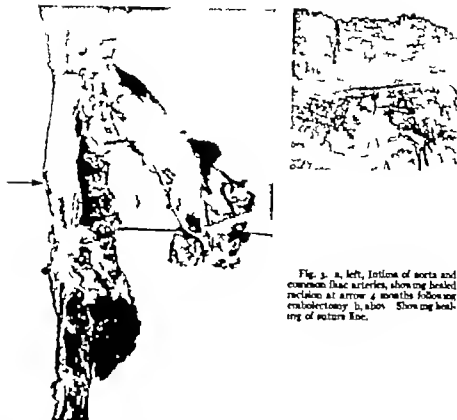


Fig. 3. a, left, Intima of aorta and common iliac arteries, showing healed incision at arrow 4 months following embolectomy. b, above, Showing healing of suture line.

ular fibrillation and insufficiency dating from rheumatic fever in early childhood. The symptoms were sudden occlusion of the aorta with pain in sacral and hypogastric regions and extending down both legs to the toes. The feet were both white. The legs were



Fig. 4. Right common iliac artery showing healed incision following embolectomy.

mottled to the upper third of the thigh. There is cyanosis of the lower abdominal region. Both legs were cold to the upper third of the thighs. There was no pulsation in either femoral or other peripheral vessels. Anesthesia and paralysis were noted from the knees distally. There was marked myocardial failure and the patient was extremely high surgical risk.

**Operation.** Through paramedian approach the iliac vessels and aorta were exposed. The embolus was demonstrated plugging the bifurcation of the aorta. It was manipulated to the right common iliac artery and removed through incision in this artery. There is some doubt if if the clot had been removed from the left and following the operation there was normal pulsation in the right femoral and peripheral vessels and pulsation in the left femoral. The left popliteal and vessels in the feet did not have normal return of pulsation although the circulation to the extremities was adequate. There was no gangrene of feet or toes. The patient made an excellent recovery and is in relatively good health, apart from the disability from myocarditis, for a period of years and months. During this period the patient had many subsequent emboli, having been admitted to hospital on four occasions. This



2 An extraperitoneal abdominal approach gives a satisfactory exposure through which the operation can be carried out without difficulty

3 In spite of the fact that most of these cases eventually die of embolism, the patient can be completely relieved of symptoms and return to the original state of health following

surgical treatment of the immediate episode.

#### REFERENCES

- KEY E. *Acta chir scand* 9 54-54
- MACFARLANE, J. A. *Brit. M. J.* 940, 94
3. MCCR. *London Arch. Surg.* 930 407-425
4. MCCR. *Canad. M. Ass. J.* 935, 31 61-66
5. MCCR. *Gordon, and MacKENZIE, Lond. Am. J. Surg.* 94 57 4-425
6. VERNON, G. *Acta chir scand* 925, 60-70

## PREVENTION OF GANGRENE FOLLOWING LIGATION OF MAJOR ARTERIES—EXPERIMENTAL STUDY

ROSE SPIEGEL, M.D. MAE FRIEDLANDER, Ph.D. SAMUEL SILBERT M.D.  
New York, New York

**G**ANGRENE of the lower extremities is a frequent consequence of aortic embolism at the bifurcation or after trauma to the major arteries of the lower extremities (2 7 10 12 13 15-17). Since the vascular bed peripheral to the site of interruption of the circulation is patent for a varying time—6 hours to a week or more—after occlusion, it appeared to us that delivery of a nutrient fluid into the arteries distal to the obstruction might be feasible. Such a procedure might maintain the viability of the extremities, permitting a more favorable outcome, such as canalization of the embolus with partial return of the circulation or development of collateral circulation (1).

We approached this problem experimentally in animals. It became necessary to develop a reliable technique for producing gangrene of the lower extremities, after which the effect of infusing nutrient material into the arteries could be evaluated.

**Production of gangrene.** Some difficulty was encountered in determining the proper arteries to be ligated in order to produce gangrene consistently. Simple ligation of the aorta at the trifurcation was a remarkably innocuous procedure in cats. They showed no restriction of muscular activity even on the first day after

operation. Bilateral ligation of the femoral arteries of the common iliacs and of both the aorta and the common iliacs failed to produce gangrene.

Only when the anastomotic branches of the deep femoral arteries were ligated in addition to the large terminal branches of the aorta or when the aorta, common iliacs, and mid-hemorrhoidal arteries were ligated did bilateral gangrene result. As shown in Table I, 10 of 12 cats developed paralysis of both lower extremities within 12 hours, and massive gangrene in 1 to 2 weeks.

We next attempted to produce unilateral gangrene in cats. Ligation of the middle hemorrhoidal common iliac and corresponding femoral anastomotic branches resulted in unilateral paralysis followed by gangrene in 4 of 5 such experiments. This appeared later than when bilateral ligations were performed.

Some control studies were also made in dogs, but these were not as numerous or as varied as in the cats. In 3 consecutive experiments in which only the 3 terminal branches of the aorta were ligated gangrene did not occur in the next 3 consecutive experiments, with the same technique gangrene did develop in 2 to 5 days.

To summarize this phase of the problem—a reliable technique for producing gangrene of the lower extremities in cats, both bilaterally and unilaterally, was developed.

*Delivery of nutrient fluid* We then studied the delivery of nutrient fluid into the femoral artery distal to the ligation. We had observed that in the gangrenous extremity of the cat, the femoral artery is patent up to a week after operation. When cut below the level of ligation, it oozes blood, and fluid can be forced into it by hand with a syringe. Either the heart's force or a substitute pulsatile pressure is required to overcome the peripheral resistance of the arteriolar-capillary portion of the circulation.

*Physiological amounts of fluid to be circulated* The blood volume of the cat is about 100 cubic centimeters, and the normal blood flow through the cat's femoral artery is 50 cubic centimeters per minute. The continuous addition of extrinsic fluid in the amounts needed for maintenance of viability of the extremity produces an unphysiological increase of blood volume, resulting in anasarca and death.

To avoid this increase in blood volume, we attempted to use the animal's own blood for delivery into the recipient artery distal to the ligation. We found the cat unsuitable for this series of experiments and transferred our studies to dogs, in whom the technical difficulties were not so great.

*Recirculation experiments* We recirculated the animal's blood from a donor vessel to the recipient femoral artery in two types of experiments. (1) A *donor artery* was connected directly to the femoral artery utilizing the heart action to transmit the blood from the former to the latter, (2) blood was aspirated from a *donor vein* by means of a machine which then forced it into the recipient femoral artery, imitating the pulsatile pressure of the cardiac action.

The details of both types of experiments will be discussed.

*Anticoagulants* The problem of anticoagulants of course became important in the work on extracorporeal blood flow. Various anticoagulants were tried.

1 Cystein hydrochloride was useless in all doses (14).

2 Dicoumarin was given by mouth for 2 days before operation. Though the coagulation time was increased to 45 minutes, a soft clot formed in the tubing in about 15 minutes.

TABLE I —LIGATION EXPERIMENTS IN CATS

	No of animals
A No paralysis or gangrene—	
Femoral arteries	2
Aorta just above trifurcation (1 paralyzed, no gangrene, died 2 days)	4
Common iliac arteries	2
Aorta and internal iliacs (1 paralyzed only on right side)	1
B Bilateral paralysis and gangrene—	
All branches of aorta at the bifurcation or trifurcation and of the deep femoral arteries of both sides	—
All branches of aorta and external iliac or femoral arteries	10 of 12
Aorta, common iliac and midhemorrhoidal arteries	2
C Unilateral paralysis and gangrene—	
Middle hemorrhoidal, common iliac and corresponding femoral profunda arteries	4 of 5

3 Chlorazol B pink (11), in doses of 100 milligrams per kilogram intravenously, was effective and had no toxic action. The substance stains the tissues a brilliant cerise for weeks. The blood tested immediately after injection of the dye is incoagulable. At the end of 6 hours the coagulation time was 15 minutes. It was necessary to give injections of half the initial dose about every 4 hours.

4 Heparin was the most satisfactory, but because of its expense was used only in crucial experiments. It was used both in divided doses and as a continuous intravenous infusion diluted with normal saline.

*Artery-to-artery* Nembutal anesthesia was used.

1 In a cat prepared with chlorazol B pink, both femoral arteries were ligated. By means of cannulas and glass-and-rubber tubing one femoral artery *proximal* to its ligation (donor) was connected to the opposite femoral artery *distal* to its ligation (recipient). A pulsation in the recipient artery was present for 2 hours, after which time the movement of the cat kinked the tubing and the blood clotted in the cannulas.

2 A similar experiment in a dog resulted in pulsation in the recipient artery for 5 hours before clotting occurred.

3 Attempts to anastomose one partly freed femoral artery to the recipient femoral artery by means of cannulas *around* the arteries were



that pressure which is necessary to overcome the peripheral resistance in the vascular bed. The normal pressure in cats and dogs is about 130 millimeters of mercury. When the animal is in shock or when there is a leak in the circuit, the pressure falls below this level, when there is partial obstruction in the outflow tubing or cannula the pressure readings climb.

7 We attempted to aspirate blood from the femoral vein, directing the cannula distally. After a few minutes, no blood could be obtained and the lumen of the vein collapsed under the aspirating force of the pump.

8 In mammals, the abdominal veins and the innominate vein form a venous reservoir. In man, it contains about 400 cubic centimeters of blood and communicates with the portal-hepatic reservoir, which contains 1000 cubic centimeters (8).

This venous reservoir was used as the source of blood for the recipient artery. This was done by directing the cannula *centrally* in the femoral vein, passing it under Poupart's ligament into the external iliac vein.

It was estimated that about a fourth of the usual blood flow to the lower extremity is necessary for maintenance of basal nutrition. In a 20 to 25 kilogram dog, the blood flow through the femoral artery is 90 to 100 cubic centimeters per minute. We estimated the blood flow in smaller dogs. The pipetting machine was set to aspirate one-quarter of the normal blood flow per minute from the venous reservoir. The blood was pumped into the contiguous femoral artery. This was done for as long as 2 hours. The details of several of these experiments are indicated in Table II.

In several of the animals there was difficulty in aspirating amounts greater than the calculated minimal requirement. More of these experiments are necessary to determine, and if possible to eliminate, the reason for the variation in the quantity which could be aspirated. For any long term experiments in recirculation of venous blood, a method of oxygenation is necessary.

#### ANALYSIS OF STUDY

We attempted to devise a means of preventing gangrene of the lower extremities in cats and dogs whose arteries had been ligated,

TABLE II — AUTOTRANSFUSION FROM EXTERNAL ILIAC VEIN TO LIGATED FEMORAL ARTERY IN DOGS

No of dog	Weight—kgm	Cubic centimeters per minute aspirated by machine	Duration of flow
374	13*	15 right extremity 15 left extremity	2½ hrs ½ hr
402	19	30	2 hrs
286	18	15 (30 not successful)	2 hrs
327	12 2	18 (30 vein collapsed)	2 hrs
453	22	60	45 mins

\*3 wks later

in order to apply it to man. Contrary to the reports of previous work (3) we had many failures before we finally developed a method by which paralysis and gangrene of the lower extremities could be produced. Numerous experiments were done in an attempt to transfuse blood from a donor artery or vein to a femoral artery distal to the site of ligation. Enough of these experiments were successful to prove the feasibility of this procedure, though many technical details remain to be worked out.

The simplest method is the autotransfusion from a donor artery of an uninvolved extremity. This requires only the use of an anticoagulant and a connecting tube. The objection which might be raised to this procedure in man, is the possible sacrifice of an important artery in a normal extremity. Experiments should be done to determine the suitability of *small* arteries as donor vessels, the loss of which would be of no serious consequence (4, 9).

To meet the objection of using an artery as the donor vessel, veins were used as the source, by aspirating with the pipetting machine and delivering the venous blood into the artery. The amount of blood obtained from the distal portion of the femoral vein is inadequate for continued delivery. The large abdominal venous reservoir was aspirated through the *central* portion of the femoral vein and was found to be a satisfactory source.

This method presents two additional problems: first, oxygenation of the venous blood. Gibbon most recently has worked extensively

on the problem of extracorporeal oxygenation of venous blood but his method has not been applicable to our apparatus. The second problem is: How much blood should be delivered to maintain the viability of the extremity? As a clinical observation in patients with peripheral vascular disease we know that a fraction perhaps one-quarter of the normal arterial blood supply is all that is essential for the preservation of an extremity. By analogy it should be possible to maintain the viability of an extremity following an acute arterial closure by a similarly reduced amount of blood. Our experiments showed that it is possible to obtain such an estimated quantity from the abdominal venous reservoir.

While the experiments described are suggestive, they are not sufficient to prove unquestionably the value of the methods. When all the technical problems have been solved the method must be applied in crucial long term experiments in animals, before its use can be recommended in human beings.

#### SUMMARY

1. Bilateral ischemic paralysis and gangrene of the lower extremities in cats was produced in 10 of 13 experiments in which the 3 terminal branches of the abdominal aorta and the anastomotic branches of the femoral arteries were ligated.

2. Unilateral ischemic paralysis and gangrene of the lower extremity was produced in cats in 4 of 5 experiments in which the middle hemorrhoidal, the common iliac, and the bi-

lateral anastomotic branches of the femoral artery were ligated.

3. In 3 of 6 experiments on dogs, gangrene of the lower extremities was produced by ligating the three terminal branches of the aorta.

4. The blood supply to the lower extremity after ligation of the common iliac artery was maintained for several hours by autotransfusion. In some experiments the blood was transfused from donor arteries. In other experiments blood was aspirated from the abdominal venous reservoir and pumped into the femoral artery by a pipetting machine.

#### REFERENCES

1. ALLEY, E. V. *Arch. Int. M.* 93, 57-60.
2. BLUMER, G. *Ann. Int. M.* 93, 490.
3. BARNES, B. and ALLEY, E. V. *J. Am. M. Ass.* 1932, 80, 873.
4. DE TAY, T. G. *J. Am. M. Ass.* 93, 975.
5. GIBSON, J. H. JR., and KIRBY, C. W. *J. Lab. Clin. M.* 94, 26-30.
6. HARRIS, J. H. FERRY, H. C. and BARNES, E. J. *Am. J. Physiol.* 91, 1.
7. LAYTON, R. W. *N. England J. M.* 94, 224-29.
8. MACLEOD, J. J. R. *Physiology and Biochemistry in Modern Medicine*. P. 56. St. Louis: C. V. Mosby Co. 9.
9. MARR, F. C. HARRIS, J. H. EMMETT, H. E. BARNES, F. J. *Surgery*, 93, 4-249.
10. MICHLESTER, A. M. *Bull. M. J.* 1936, 44.
11. MONROE, R. *Science*, 1939, 89, 249.
12. PRUESE, H. E. *Ann. Surg.* 91, 97-124.
13. PYKE, MAYO Clin. 93, 5.
14. PUTNAM, T. J. and HOFFER, P. F. A. *Am. J. M. Sc.* 93, 98-102.
15. RADEY, I. S. and WOOD, F. C. *Ann. Surg.* 94, 14-24.
16. STEVEN, D. W. *Surg. Gyn. Obst.* 95, 20-35.
17. WELCH, H. *Embodiment, Abell's System of Medicine*. Vol. 6, p. 775. New York: Macmillan & Co. 1909.

# THE USE OF AUTOTRANSFUSION IN SURGERY OF THE SEROUS CAVITIES

R ARNOLD GRISWOLD, M D, F A C S, and ALVIN B ORTNER, M D,  
Louisville, Kentucky

**E**MERGENCY surgery of the serous cavities of the body, particularly in the field of trauma and of ruptured ectopic pregnancy, is directed principally to the control of hemorrhage and the replacement of blood in an often exsanguinated patient. The time factor is extremely important. This is true, not only in regard to hemostasis, but also in the replacement of blood when large amounts have been lost rapidly. It is obvious that the prevention of shock due to hemorrhage by rapid replacement therapy is to be preferred to the frequent custom of instituting therapy only after shock has become evident. Even after shock is present, the earlier it is controlled the less likelihood there is of irreversible changes.

Hamilton in a review of 336 cases of penetrating wounds of the abdomen found that hemorrhage was the greatest factor in the mortality. In his series there was a mortality of 27.8 per cent in cases of hemorrhage of less than 500 cubic centimeters, 51.3 per cent in those between 500 and 1000 cubic centimeters and 73.4 per cent in those with over 1000 cubic centimeters. This has been borne out by others. Billings and Walking, Loria, Rippey, Taylor, and Mason.

While wounds in the superficial portion of the lungs are usually not dangerous from the standpoint of hemorrhage, there is a definite group of thoracic wounds in which exsanguination may occur. Griswold and Maguire state

"When massive cardiac hemorrhage into the pleura is occurring the exact diagnosis of wound of the heart may be more difficult, but the indications

From the Department of Surgery, University of Louisville School of Medicine and the Louisville General Hospital, Louisville, Kentucky.

Prepared for presentation in the Forum on Fundamental Surgical Problems before the Clinical Congress of the American College of Surgeons, which was to have been held in the fall of 1942 but was cancelled because of the war.

† Dr. Griswold now Lieutenant Colonel, Consultant in Surgery for the Fourth Service Command.

for immediate operative intervention are clear and imperative. Bleeding from the parenchyma of the lung in wounds of the thorax may be massive, but is slow and seldom requires operative hemostasis. On the other hand, free bleeding from the heart, great vessels, internal mammary, or intercostal arteries is fast and profuse. Rapidly progressive shock is present early and death may quickly ensue unless hemorrhage is checked."

Elkin advises immediate operation when there is evidence of rapidly increasing hemorrhage, or a wound of the heart. In his series of patients with thoracic wounds, the most common cause of death was shock and hemorrhage. He states

"Treatment of this class of patients presents the most difficult problem and 18 of them died within the first 24 hours after admission without reacting from shock. Some of that number may have been saved by operation. This would have necessitated open thoracotomy and lung suture."

We believe that in certain cases of this type, aspiration of blood from the thorax, replacement by air, and transfusion of the blood may be lifesaving without subjecting the patient to risk of open thoracotomy and lung suture.

Likewise, in ruptured ectopic gestation the principal cause of death is from exsanguinating hemorrhage.

A review of such cases by any surgeon will show that an outstanding proportion die on the operation table or shortly after operation, due to tardy or inadequate replacement of the lost circulating blood volume. The time lost in grouping donors, matching blood from a bank, or even obtaining plasma in sufficient amounts may be fatal. Also, the amount of blood of correct type and of plasma available from donors, blood banks, etc., frequently is insufficient to supply the needs of patients who have lost large amounts of blood (1500 to 2500 cc). The usual 500 cubic centimeter transfusion is the donor's dose and bears no relationship to the needs of the patient.



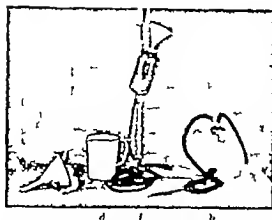


Fig. Autotransfusion outfit used in all cases of hemorrhage into body cavities: a, Pool suction tip; b, 500 cubic centimeter bottle; c, 1/16 inch o-ring stopper containing citrate solution; d, tube remaining in operating room section; e, 500 cubic centimeter graduated flask; f, fixed 1/16 inch glass filter; g, latex rubber outfit; h, Murphy drip.

All too often one sees several pints of blood thrown away from the body cavity of patients who are bleeding to death. It is our belief that this autogenous blood represents the most readily available abundant rapid and safe replacement therapy for these urgent cases. Large quantities of blood are often immediately accessible the blood is compatible and needs no crossmatching the danger of transmission of disease i.e. syphilis, malaria, etc. is absent as is the possibility of an allergic response.

In 1874 it occurred to William H. H. Moore after seeing a patient exsanguinate from post partum hemorrhage that had he collected defibrinated and reinfused the blood, it would have offered the woman her only chance of life.

The first reference to the actual infusion of autogenous blood was made by John Duncan in 1885. He was faced with the problem of thigh amputation on a patient whose leg had been crushed and who had become moribund during transportation to the hospital. Donors were not immediately available so during the amputation approximately 3 ounces of blood which fell were collected in a dish containing phosphate of soda. This was then reinfused into the femoral vein on the amputation stump. The case terminated successfully the

procedure was repeated in other instances and he stated:

I am convinced that this little operation, so easily performed will save many lives in the collapse of primary amputations and will prove beneficial to the wasted and anemic patients in the major amputations for disease.

The first report of autotransfusion of blood collected from the peritoneal cavity was given by Thiers in 1914. In the cases he reported, ruptured ectopic pregnancy was the cause of hemorrhage. In 1936 Watson and Watson in a review of the American literature reported 275 cases and added 2 of their own. The largest individual series was that of L. J. Tiber who had used the procedure in 159 cases of ruptured ectopic pregnancies.

In spite of these reports the autotransfusion has never enjoyed widespread popularity. Too frequently it has been unjustifiably condemned and the use of it neglected when it would have been of utmost value in the restoration of blood volume. This attitude has been derived from reports of bad results, which we believe were due not to the method, but to errors in its use.

In this report, 100 consecutive autotransfusions have been analyzed. The first of these were done in cases of intraperitoneal hemorrhage due to ruptured ectopic pregnancy but later the transfusion of autogenous blood was used in a large variety of emergency cases with internal bleeding.

Table I shows the type and number of cases in which autotransfusion has been used. The marked increase in cases since 1937 was due to increased emphasis on the procedure and the use of blood in cases of hollow viscus perforation. Also at this time a suction apparatus was devised to collect the blood. The apparatus is very simple (Fig 1) but serves the purpose well and is easily sterilized and placed upon the instrument table. The unit consists of a 500 cubic centimeter graduated flask fitted with a rubber two-hole stopper and glass connecting tubes. Before the operation is begun 50 cubic centimeters of a 2 per cent sodium citrate solution is placed into the flask. One tube is then attached to the suction and the other to the Pool suction tip. When in use the flask acts as a trap, collecting the blood.



TABLE II.—AMOUNT OF AUTOTRANSFUSIONS

Amount of blood—c	No. Cases
Less than 50	
50 to 100	
100 to 250	3
250 to 500	4
500 to 1000	
1000 to 2000	3
2000 to 3000	3
Not recorded	8

Disadvantages and contraindications to the use of autotransfusion have been given in the literature, and reactions ranging in severity from mild increase in temperature or nausea and vomiting, to fatalities, have been reported.

The causes usually given for reaction are (1) toxins or foreign protein coming from necrotic or decomposing tissue which may be in the body cavity during or following the hemorrhage i.e. the gestation products of a tubal pregnancy or crushed liver tissue in cases of trauma (2) bile mixed with the blood in injuries to the liver (3) the use of portal blood before it has gone through the liver (4) bacterial contamination from penetration of a hollow viscus (5) hemolytic changes of the blood.

*Toxins or foreign proteins caused by necrosis of tissue.* In 22 cases of ruptured ectopic pregnancies reported in this series there were no deaths and only 1 reaction. The type reaction was not stated only that it was mild. In this case the patient had been admitted 6 days prior to operation with a provisional diagnosis of ruptured ectopic gestation. At operation 1500 cubic centimeters of dark unclotted blood was found in the peritoneal cavity. The reaction caused by the infusion of this blood was probably due to hemolysis and will be discussed under that heading.

In Tiber's (24) series of 189 cases of ruptured ectopic pregnancies which received autotransfusion, 123 patients received this alone while in the remaining 66 patients the autogenous blood was supplemented by transfusion from donor sources. In the former cases the mortality was 0.81 per cent while in the latter it was 3.03 per cent. Three fatalities were reported with the cause of death as blood dyscrasia, and in all 3 operation was done after 72 hours. The term, blood dyscrasia, is very vague and it must be assumed because

of experimental work from other sources (12, 19) on blood allowed to remain in a serous cavity that it was a hemolytic reaction. Since the publication of his report Tiber has used the autotransfusion in 250 more cases, in none of which was there a reaction (25).

Trimble (16) in discussing a case reported by Allen, in which 800 cubic centimeters of blood from the peritoneal cavity was reinfused in a patient with a ruptured liver and who died 56 hours later stated that the cause may have been due to damage done by toxins elaborated by a ruptured liver in which autolysis takes place so rapidly.

The 24 cases of liver injury in this series are presented in Table III. In this group there were 9 fatalities, 3 occurring on the operation table and 5 within the first 3 postoperative days. The remaining 1 had an associated injury to the right kidney which necessitated nephrectomy. Autopsy following death on the 10th day showed the remaining kidney to be almost totally replaced by a solitary cyst. In all of the fatal cases there were severe associated injuries and in no instance was death believed due to the reinfused blood. In the 15 cases which survived there were no reactions. In 2 of these, large masses of tissue were torn from the liver. In wounds of the spleen where there was crushed splenic tissue and blood was reinfused, there was likewise no reaction.

*Bile mixed with the blood and injuries to the liver.* The belief that bile is toxic when present in the blood and in sufficient quantities fatal has been confirmed experimentally (30). When bile is injected into the blood stream it has a depressing effect on the central nervous system and heart muscle from its direct action on these organs, and destroys the red blood cells, as do saponins by reducing the surface tension (6).

Undoubtedly in injuries of the liver there are varying amounts of bile mixed with blood in the peritoneal cavity. The most important factors in the amount of bile which escapes from the liver are the type of injury and the time between injury and operation. In stab wounds the amount of bile liberated is probably minimum while in crushing wounds or fractures of the liver a much larger quantity is free and mixed with the blood. However in

TABLE III—CASES WITH INJURY TO THE LIVER

Cases Associated injuries	Type of injury	Autotransfu- sion in		Remarks
		c.c.*	Re- sult	
1 —	N P	500	D	Died 2d postoperative day. Associated injuries—ruptured spleen and fractured femur
2 +	N P	1500	I	60 grams mass of liver tissue free in peritoneal cavity. Associated injuries—ruptured kidney and fractured radius
3 +	N P	500	I	Associated injury—fractured skull
4 0	N I	700	D	Died 1d postoperative day. Severe injury to liver with 5 by 8 cm. piece of liver free in peritoneal cavity. Autopsy revealed necrosis of the liver and 1000 c.c. of blood in the peritoneal cavity
5 0	N P	1500	I	
6 +	N P	1000	I	Associated injury—contusion of the brain
7 0	N P	800	I	
8 0	C S W	300	I	Clay 3 cm. piece of liver tissue floating free in the peritoneal cavity
9 0	S W	1000	I	
10 +	C S W	1000	D	Died day of admission. Autopsy revealed penetration of chest, left lung, diaphragm, stomach and liver. Also gunshot wounds of mouth, penis, and perineum. Massive hemothorax
11 +	C S W	1500	D	Died during operation—large perforation of inferior vena cava
12 +	C S W	800	I	Associated injuries—crushing wound of spleen, perforation of stomach with gastric contents in peritoneal cavity
13 +	C S W	700	I	Associated injury—hematoma around kidney
14 +	C S W	200	I	Associated injuries—perforation of stomach and penetration of kidney necessitating nephrectomy
15 0	S W	500	I	
16 +	C S W	2000	D	Died on 2d postoperative day. Autopsy revealed rupture of accessory splenic vein, ruptured kidney and pancreas, perforation of stomach and jejunum
17 +	C S W	2500	D	Died during operation—perforation of aorta
18 +	C S W	1200	D	Died during operation—perforation of inferior vena cava, kidney and small bowel
19 +	C S W	900	I	Two perforations of stomach
20 0	S W	300	I	
21 0	C S W	300	I	
22 +	C S W	700	D	Right nephrectomy because of severe injury to right kidney. Patient died of uremia 19th postoperative day and autopsy revealed left kidney replaced by a solitary cyst
23 0	C S W	700	I	
24 +	C S W	800	D	Died 1d postoperative day. Associated injuries—rupture of spleen and perforation of diaphragm

N P = Nonpenetrating wound  
C S W = Gunshot wound  
S W = Stab wound

\*Cases 4 and 16 died following transfusion. No reaction in other cases.  
I = Improved, D = died

the 7 nonpenetrating wounds which were crushing in nature, there were no hemolytic reactions or any evidence of depression of heart action.

In Case 8 (Table III) a 6 by 3 centimeter piece of liver was torn from the left lobe by gunshot wound. This mass was floating free in the peritoneal cavity. It was removed and

350 cubic centimeters of blood was reinfused. No reaction followed this and the patient had an uneventful recovery. The temperature rose to 102.6 degrees and the pulse was 104 per minute on the 5th postoperative day and returned to normal on the 8th postoperative day remaining so throughout the hospital course. Also in Case 2 (Table III) a 250 gram mass of liver tissue was avulsed from the right lobe being attached only by a thin pedicle and the gall bladder was torn from its bed being attached by the cystic duct. In this case the liver pedicle was divided and the free mass of liver tissue removed as well as the gall bladder. Nephrectomy was done for an associated fragmentation of the right kidney. This patient received 1500 cubic centimeters of blood from the peritoneal cavity. Recovery was uneventful the temperature never exceeded 101.2 degrees, and there was no bradycardia or abnormality of the pulse rate. On the 9th postoperative day the temperature was normal and the patient was discharged improved on the 20th day.

Although aware of the toxicity of bile in the blood, injuries to the liver have not been a contraindication to autotransfusion on our service and no serious reactions have taken place.

*The use of portal blood before it has gone through the liver.* The hemodynamic crisis, caused by injecting blood from the portal system into the systemic circulation as described by Widal was not found present by Filatov in his experiments on autotransfusions in dogs and he concluded that the use of portal blood was harmless. Likewise in the cases of this series in which the hemorrhage or a portion of it was from the portal circulation there was no such reaction found.

*Bacterial contamination from penetration of a hollow viscus.* There are but two reports in the literature in which blood from the peritoneal cavity was reinfused following the perforation of a hollow viscus. The case of Wolf had a fatal termination following the use of blood from the peritoneal cavity in which there were perforations of the stomach and injury to the liver. Von Schalek in 1927 reported the use of and recommended autotransfusion as a lifesaving procedure in pene-

trating wounds of the abdomen with or without hollow viscus penetration.

Bacterial contamination of the blood due to perforation of a hollow viscus has been one of the major contraindications to the use of autotransfusion. It has been the opinion that by the use of such blood septicemia and septic emboli would be the natural sequelae seriously complicating an already unhappy situation. We have not found this to be true. A temporary bacteriemia does occur when contaminated blood is infused, just as it does when organisms are freed into the peritoneal cavity but the blood stream destroys the bacteria without resulting infection.

Experimental evidence with normal animals has shown that there is a rapid passage of bacteria from the peritoneal cavity via the diaphragmatic lymphatics, into the blood stream. Subsequent studies of the fate of the bacteria revealed that they were cleared relatively rapidly from the blood stream, and, after their disappearance viable bacteria could still be isolated from the liver and spleen (26).

The cases in this series cannot be classified as normal because of the acute anemia resulting in a lowered resistance and it is realized that by the infusion of contaminated blood a greater number of bacteria is placed into the circulation. However by replacement of the blood and maintenance of adequate circulation the resistance of the host more than compensates for the added number of bacteria. Should the virulence of the organisms be so great that the blood stream is unable to cope with them and a fatal septicemia occur the same termination would probably result from the migration of the bacteria through the lymphatics, or death would occur from an overwhelming intraperitoneal infection.

If a sufficient quantity of sterile compatible blood is immediately available its use would be safer than the use of contaminated blood. In such an instance the resistance of the host is increased without an increase in the number of organisms, while both are increased when contaminated blood is used.

In 1937 for the first time on the surgical service of the Louisville City Hospital, blood from the peritoneal cavity that had been

TABLE IV—CASES WITH PERFORATIONS OF A HOLLOW VISCUS

Cases Associated in junes	Type of Injury	Hollow vis- cus penetra- ted	Autotransfu- sion in		Remarks
			c.c.*	Result	
1 0	N.P	Ileum	500	I	Two severe reactions during postoperative course from transfusions of blood taken from Blood Bank
2 +	G S W	Stomach	700	I	Bullet traversed left pleural cavity and empyema later developed on this side
3 +	G S W	Stomach	1000	D	Died 4 hours after operation Autopsy revealed penetration left lung diaphragm stomach and liver Also gunshot wounds of mouth penis and perineum Massive hemothorax
4 +	G S W	Colon	400	I	Perforation of the entire wall of the colon (questionable)
5 0	G S W	Small bowel tr colon descending colon	?	D	Died on 84th postoperative day During postoperative period developed peritonitis and subphrenic abscess The latter was drained on two occasions and the abdomen re-explored on one occasion
6 +	G S W	Gall bladder	1500	D	Died during operation Large perforation of inferior vena cava
7 +	G S W	Stomach	800	I	Penetration of pleural cavity and injury to spleen with splenectomy
8 +	G S W	Stomach	935	D	Died several hrs after operation—autopsy revealed massive hemothorax with exsanguination Also only one of two perforations of the stomach had been closed
9 +	G S W	Jejunum tr colon	700	D	Died a few minutes after operation Great difficulty in controlling retroperitoneal hemorrhage during operation
10 +	G S W	Small bowel	600	D	Died during operation
11 +	G.S.W	Duodenum ileum, tr colon	?	D	Died 17 hrs after operation Loop of ileum resected because of severe damage it sustained Also perforation of the inferior vena cava
12 0	G S W	Stomach tr colon	750	D	Died 13 hrs after operation Obstructive resection because of severe injury to colon
13 +	G S W	Stomach	400	I	Associated injuries to kidney and liver
14 0	G S W	Small bowel	1300	D	Died day of operation Pulse and blood pressure could not be obtained the last 35 minutes of the operation
15 +	G S W	Ileum	1000	D	Injury to iliac and femoral vessels the latter ligated Sudden death 2d postoperative day Death embolic in nature embolus believed to come from injured vessels
16 0	G S W	Small bowel	1500	I	1st postoperative day comatose 2d postoperative day signs of pulmonary infarction developed Good recovery
17 +	G S W	Jejunum ileum descending colon rec- tum	1500	D	Improper filtration of the blood Gross contamination plugging needle Embolic death on 3d postoperative day
18 +	G S W	Stomach jejunum	2000	D	Died 2d postoperative day Autopsy revealed ruptured accessory splenic vels hemoperitoneum ruptured kidney and pancreas, perforation of stomach and jejunum
19 +	G S W	Stomach	2500	D	Died during operation Associated injuries—penetration of lung diaphragm abdominal aorta liver and pancreas
20 +	G S W	Ileum cecum sigmoid	2000	D	Died during operation. Associated injuries—penetration of lung diaphragm abdominal aorta liver and pancreas
21 +	G S W	Ileum	1200	I	
22 +	G S W	Small bowel	1200	D	Died during operation Associated injury—perforation of inferior vena cava
23 +	G S W	Duodenum	1500	D	Died on 4th postoperative day Autopsy revealed peritonitis subphrenic abscess pulmonary edema
24 +	G S W	Stomach	900	I	Associated Injury to liver
25 +	G S W	Stomach small bowel colon	?	D	Died during operation Associated injuries—ruptured spleen and liver

N P = Nonpenetrating  
G S W = Gunshot wound

\*Reactions noted in Cases 15 16 and 17 only none in other cases  
I Improved D died

contaminated by hollow viscus content was used for autotransfusion.

#### CASE REPORTS

**J. W. G. No. 705** A 39 year old white male was admitted to the surgical service 1 hour after he had received gunshot wounds of the thigh and thorax. The entry into the thorax was on the left, at the 9th intercostal space and was followed by the vomiting of blood. On admission the temperature was 97 degrees, pulse 100, respiration 23 per minute and the blood pressure 74/50. The patient was in shock and the abdomen was tender and rigid. A diagnosis of gunshot wound penetrating the thorax, diaphragm, and abdomen with visceral perforation and internal hemorrhage was made. Supportive treatment was given and 34 hours following admission an exploratory celiotomy was done. There was a large amount of blood in the peritoneal cavity and perforations of the anterior and posterior aspects of the stomach were encountered. During the course of the operation the patient's condition became worse and he ceased to breathe. Cocaine was given and respiration again started. Seven hundred cubic centimeters of blood which was removed from the peritoneal cavity was then administered intravenously in place of the saline infusion he had been receiving.

During the postoperative course the patient developed a wound infection and an empyema of the pleural cavity which the bullet had traversed. From both *Staphylococcus albus* was isolated. There was no evidence of septicemia. The patient responded to all treatment and was discharged improved on the 37th hospital day.

In this case, the reinfusion appeared to be a lifesaving procedure and there was no ill effect from the blood. It was believed that the need of blood was greater even though it be contaminated, than the danger involved in its use.

Twenty four more cases of abdominal trauma with hollow viscus perforation and hemorrhage have since received autotransfusion (Table IV). All but 1 which was not penetrating, were due to gunshot wounds of the abdomen. Seventeen had a fatal termination giving a mortality of 68 per cent. Of the deaths, 6 occurred on the operating table and 6 more within the first 18 hours of the postoperative course. In all of these cases severe injuries existed and in none did death appear to have been caused by septic emboli coming from the autogenous infused blood. In 3 others, in which death occurred shortly after operation, one on the 2d day and the other on

the 4th day there was no evidence that the reinfused blood was contributory to the death. One patient died on the 84th hospital day following a very stormy course during which peritonitis and a subsequent subphrenic abscess developed. Blood cultures were persistently negative. Of the 2 remaining fatalities, death in one was directly attributed to the autotransfusion while in the other the use of contaminated blood could not be ruled out as a contributory factor to the death.

**J. S. No. 708** A 39 year old white male was admitted shortly after gunshot wound of the abdomen. The patient as ill developed and nourished white male semistarved, in shock, and having strong alcoholic odor to his breath. The pulse rate was 1 per minute and the blood pressure 60/30. Intravenous glucose-saline solution was started on the ward and blood crossmatched for transfusion. Two and one-half hours following admission the pressure rose to 85/50 and exploratory celiotomy was done. The peritoneal cavity contained contaminated blood and there were 3 perforations of the small bowel, 3 of the descending colon and 2 in the rectum. During the operation approximately 1,000 cubic centimeters of blood, large portion of which was coming from the retro-peritoneal space was removed. The blood was markedly contaminated, containing formed feces, but because of the extremely poor condition of the patient and the inability to obtain sufficient blood, 500 cubic centimeters was reinfused. During the infusion the needle became plugged with fecal debris, and it was found that the blood was not being properly filtered.

Sixty-two hours after operation the patient developed marked dyspnea, cyanosis, and suppression of breath sounds. One hour later signs of massive pulmonary edema developed, and death ensued shortly. At autopsy multiple pulmonary emboli and massive pulmonary edema were found.

In this case there was a definite break in technique. Gross debris was allowed to enter the blood stream giving rise to septic emboli. The bad result cannot be attributed to the procedure but to error in the method of its use.

In the other case death due to a large pulmonary embolus occurred on the 2d postoperative day. In this instance there were perforations of the small bowel and severance of the femoral artery and vein. The origin of the embolus could not be definitely determined, but it was felt that it had arisen from the injured vessels.

There was but 1 reaction in the 8 cases that recovered. In this case (Case 16, Table IV) there were 4 perforations of the small bowel. At operation 1500 cubic centimeters of blood from the peritoneal cavity was returned to the patient. On the 1st postoperative day the patient became comatose, and on the 2d developed signs of pulmonary infarction. There was good recovery following the use of sulfathiazole, and he was discharged improved on the 17th hospital day.

In 4 cases, not included in this group, there was severe trauma to the kidney and in each nephrectomy was performed. In these cases the blood which was reinfused contained varying amounts of urine which had escaped from the damaged kidney. No reactions followed the use of such blood.

*Hemolytic changes in the blood.* Studies on blood withdrawn from the peritoneal cavity of dogs at varying intervals following intra-abdominal hemorrhage have shown that there are no changes within 6 hours following the hemorrhage. After 6 hours there is an increase in the size and shape of the erythrocytes. No hemolysis was observed before 16 hours, but after 24 hours there was a large number of destroyed red blood cells and intensive hemolysis (12). Ricci and DiPalma have found the erythrocyte count of intraperitoneal blood normal as late as 72 hours following tubal rupture. Most reactions following autotransfusion, which have been reported, have been due to the use of blood that has been in the peritoneal cavity for more than 24 hours.

In the 3 fatalities in Tiber's series (24), the blood reinfused had been in the peritoneal cavity more than 72 hours. Coley used blood which had been in the peritoneal cavity for 5 hours following rupture of the spleen. On the 2d day that patient's urine was port wine color but there were no other signs of reaction and the patient made a good recovery.

In the series here reported, in only 1 instance was blood used for autotransfusion that had been in a serous cavity for more than 24 hours. In this case a tentative diagnosis of ruptured ectopic pregnancy was made and the patient was observed for 6 days prior to operation. On opening the peritoneal cavity approximately 1500 cubic centimeters of dark unclotted

blood was found. After 400 cubic centimeters had been returned, a reaction was noted. The reaction was mild, but the type was not recorded on the chart. The postoperative period was uneventful, the temperature never exceeded 100.6 degrees, and the patient was discharged improved 16 days later.

A widely accepted explanation of the hemolytic reaction, based on the work of Baker and Dodds, is that in an acid urine the free hemoglobin is precipitated in the renal tubules. A mechanical blockage ensues, and oliguria or anuria with uremia develops. DeGowin, Osterhagen and Andersch (7) in their experimental work found that when urine is alkaline the intravenous injection of a large amount of dog hemoglobin into dogs seems to be innocuous. When the urine is acid, transfusions of hemoglobin sooner or later produce renal insufficiency and it appears to be the result of the obstruction of the tubules with masses of pigment derived from hemoglobin, thus substantially confirming the experiments performed on rabbits by Baker and Dodds.

Further study by DeGowin, Warner, and Randall (8), on the human kidney following fatal transfusion reactions, revealed the same process present but to a lesser degree and that, although renal insufficiency in some cases may be due to mechanical blockage, in the majority it is probably due to a nephrotoxic substance which causes degeneration of the tubule epithelium and interstitial edema.

De Nevasquez was unable to find evidence of tubule obstruction in fatal cases following transfusion, or in animals after injection of hemoglobin, and concluded that the changes in the so called "transfusion" kidney do not appear to support the view that simple mechanical blockage of the tubules by altered blood pigments is responsible for the anuria seen in fatal cases of blood transfusion.

Although the pathologic physiology which occurs when hemolyzed blood is given intravenously is not agreed upon, it is well established that it may be toxic and under certain conditions fatal.

Hemolysis of the blood should limit the procedure but very little. Seldom is there massive internal hemorrhage that goes for



TABLE 1—MORTALITY TABLE

Type of case	No. of cases	No. of deaths	Mortality percent
Ruptured ectopic pregnancy			
Penetrating wounds of thorax	9	6	31.5
Nonpenetrating wounds of the abdomen			
Penetrating wounds of abdomen	19	5	13.8
Without hollow viscus perforation		9	50
With hollow viscus perforation	3		5.3
Combined cases	5	7	68
	100	30	30

more than 24 hours without operation or death ensuing. In those cases that do there is time to obtain sufficient quantities of blood to replace that which has been lost.

## SUMMARY

One hundred cases of autotransfusion following internal hemorrhage are reported in this paper. In 22 hemorrhage was due to ruptured ectopic gestation while in the remaining 78 penetrating and nonpenetrating trauma to the thorax and abdomen was the etiological agent. There were 30 deaths in this group making a mortality of 30 per cent. All of the deaths occurred in the traumatic cases, giving this group a mortality of 38.4 per cent. By dividing the traumatic cases into groups in respect to the type and location of the trauma, the following is found. In 19 penetrating wounds of the thorax there were 6 deaths, a mortality of 31.5 per cent. In 21 cases of nonpenetrating wounds of the abdomen there were 5 deaths, a mortality of 23.8 per cent. Nineteen deaths occurred in the 38 penetrating abdominal wounds, the mortality being 50 per cent. The highest mortality 68.0 per cent occurred in abdominal wounds with hollow viscus perforation. In 25 cases, 17 terminated fatally. In all but 1 of these injury was due to gunshot wounds and hemorrhage was greater in this group than in the others (see Table V).

One fatal reaction occurred in the 100 cases, giving a percentage of 1.0. In this case there was a break in the technique of filtering the blood. In 2 other instances there were reactions from which the patient recovered, giving a combined percentage of 3.0 for reactions. There was a doubtful reaction in 1 case but it could not be definitely established that this was due to the reinfused blood. In 1 case the

patient had no reaction from the autogenous blood but had severe reactions on 2 occasions from blood obtained from the bank (Case 1 Table IV).

It has been shown that some danger accompanies the use of autogenous blood, especially the use of contaminated blood. Sterile compatible blood from a donor source is safer but it must be in sufficient quantities without delay and it must be remembered that 500 cubic centimeters is the donor's dose and not the recipient's. The use of autogenous blood even though it be contaminated, is safer than allowing the blood volume to remain depleted.

## CONCLUSIONS

1. Hemorrhage is the greatest single factor in the mortality of wounds of the serous cavities.
2. Autotransfusion is a valuable adjunct in the treatment of internal hemorrhage.
3. With armies in the field and trauma on the increase due to high velocity vehicles, both in military and civilian life this procedure should be held in a foremost place in the minds of those doing emergency surgery.
4. A simple suction apparatus is described which is more efficient in the collection of blood than mopping it from the body cavities.
5. The technique particularly as regards filtration must be rigid.
6. Bile mixed with blood due to injury of the liver or biliary tree and bacterial contamination due to hollow viscus perforation, add danger to the procedure however this danger is not so great as might be thought and the need of blood is frequently far greater than the danger involved.
7. Old blood because of hemolytic changes, should not be used.
8. Alkalinization of the urine may prevent reactions caused by partial hemolysis of the blood.

## REFERENCES

1. BAKER, S. L. and DODGE, E. C. *Brit. J. Exp. Path.* 935, 6 247-260.
2. BELLINGR, A. E. and WALKER, A. *Ann. Surg.* 93 94.
3. COLBY, B. L. *Ann. J. Surg.* 928, 4 134.
4. COMBOS, A. *Rev. gyn. obst.* 937 3 447-455.
5. Edm. *Rev. med. et chir.* 933, 46 809-130.



# TRIPHALANGEAL THUMB

## Report of Six Cases

PAUL W. LAPIDUS M.D. F.A.C.S. FRANK P. GUIDOTTI M.D. Major M.C., U.S.A.  
and C. J. COLETTI M.D. Captain, M.C., U.S.A., New York, New York

### REPORT OF CASES

THE rarity of the triphalangeal thumb warrants recording of 6 additional cases. Although several case reports can be found in the literature it must still be considered as a rather infrequent anomaly. Dr M. Pomeranz, roentgenologist of the Hospital for Joint Diseases, has informed the authors that during the past 25 years there has not been a single case of triphalangeal thumb seen in his department.

In the first 3 cases reported here the men were seen a few months apart during daily examinations of draftees. No similar cases were encountered among more than 75,000 other men who had physical examinations despite the fact that the authors were on constant lookout for anomalies.

In the fourth case the patient was the father of one of the draftees and was examined in the office of the senior author.

Frere (1930) reported one case exactly like Case 2 to be described by the writers. In this case a male negro both thumbs were affected and his mother had one similar abnormal thumb. Both thumbs of the grandmother also were said to be triphalangeal.

Haas (1939) gave histories of 3 families in which 1 or more members possessed triphalangeal thumbs.

The cases of triphalangism of the thumb reported in the literature prior to 1935 were reviewed by Stieve (1915). In addition he presented a case of bilateral triphalangeal thumbs associated with congenital afasia and in a 19 year old male. No other members of the patient's family had any deformity of their hands. A drawing of the roentgenogram, in dorsopalmar view is exactly like that in Case 1 (Fig. 1).

It is interesting that triphalangism of the hallux has also been seen though of even greater rarity than of the pollex. From the Recruiting and Induction Station, United States Army, New York.

**CASE 1.** R. W. white male aged 30 years, was examined by the writers at the Induction Station. He was a baker by occupation and experienced no difficulty in performing his work. A history of any similar deformity in his family could be obtained. His physical examination was entirely negative except for both thumbs, these were slightly longer than usual. The tip of each thumb reached to the level of the middle of the proximal phalanx of the index finger.

The nail phalanx of each thumb as held in slight palmar flexion and ulnar deviation pointing toward the index finger. On palpation, the impression was gained that there was an additional phalanx interposed between the basal and nail phalanges of both thumbs. The roentgenogram of the thumbs on dorsopalmar exposure (Fig. 1) showed that the head of the proximal phalanx had a well outlined condyle on its radial and ulnar sides. There was a wedge-shaped ossicle, 9 millimeters long and 7 millimeters wide (the width being measured from the apex of the wedge to its base) interposed only between the radial condyle of the head of the proximal phalanx and the corresponding radial half of the nail phalanx.

The ulnar condyle of the head of the proximal phalanx, however articulated directly with the ulnar side of the nail phalanx. Correspondingly, the base of the nail phalanx was somewhat broader than usual and had two facets forming an angle of about 30 degrees pointing proximally, one clear facet for the proximal phalanx and the other the radial facet for the middle phalanx.

The lateral view (Fig. 2) showed the same wedge-shaped ossicle interposed mainly on the dorsal aspect of the interphalangeal joint of the thumb. The proximal phalanx appeared to be of normal height and proportions. A normal radial sesamoid was present at the first metacarpal head of both thumbs. The first metacarpals appeared to be slightly smaller and thinner than could be expected. The bones of the 2nd, 3rd, 4th and 5th fingers presented no abnormalities. Likewise the feet (which are not roentgenographed) appeared to be normal.

**CASE 2.** O. S. colored male aged 27 years, was also seen at the Induction Station. He was a carpenter by trade, and his anomaly did not interfere with his work. Except for his thumbs, the man was well built, in good health and of parental health in his family. Questioning revealed a similar bilateral deformity only in his father who is deceased. His



Fig 1 Case 1 Dorsopalmar view of both thumbs a, left, b, right. Note the wedge shaped "middle phalanx" interposed between the radial half of the nail phalanx and the basal phalanx. The ulnar half of the basal phalanx and the ulnar half of the nail phalanx articulate directly with each other. The punctate outline reconstructs what may be the absent distal part of the nail phalanx of an apparently bifid thumb.

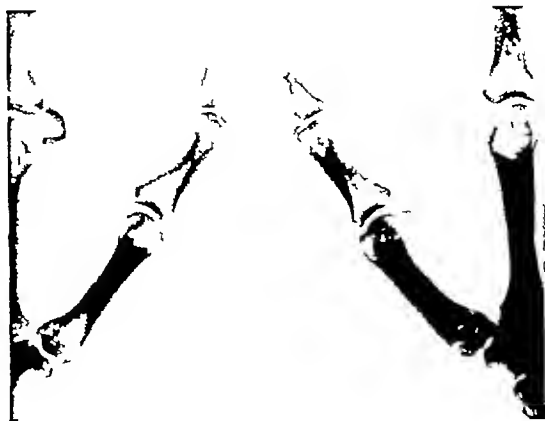


Fig 2 Case 1 Lateral view of both thumbs a, left, b, right. Note the wedge shaped "middle phalanx" interposed between the basal and nail phalanges on the dorsal and radial aspects. Note also that the basal phalanges appear to be normal, while the first metacarpal may be slightly smaller and thinner than normal.

nine sisters and two brothers were said to have normal hands.

On examination, both thumbs were found to be unusually long, when the thumbs were held close to the index, their tips extended almost to the level of the proximal interphalangeal joint of the index finger. Three definite phalanges with proximal and distal interphalangeal joints were present in each thumb. The nail phalanx of each thumb was held in palmar flexion at about 135 degrees so that its tip pointed toward the index finger. The proximal phalanx of the thumbs was unusually long, measuring about 4 centimeters on the roentgenogram (Fig 3). The middle phalanx was small, measuring 15 millimeters on the right and 12 millimeters on the left side, both being trapezoid shaped, especially the left. Each nail phalanx appeared to be normal, and no was 2 centimeters long in both thumbs.

Grossly, there was normal mobility of both thumbs, which could be opposed and flexed in normal fashion. Motion in the metacarpophalangeal joints was possible between 180 degrees of extension and 90 degrees of palmar flexion. The proximal interphalangeal joint could be moved between 170 degrees and 100 degrees of palmar flexion. The distal interphalangeal joint had the least range of motion, being between 135 and 125 degrees of palmar flexion. The lesser fingers and both hands presented no other abnormalities, except that the thenar eminences were slightly flatter than in a normal hand. Both wrists and all other joints of the body, including the feet, were normal.

**CASE 3** J. G., white male, aged 19 years, was examined at the Induction Station. He was a clerk by occupation. Triphalangism of both thumbs was noted in combination with bilateral congenital absence of the pectoralis major and minor muscles and slight pectus excavatus. The young man stated that his father had similar thumbs.

Examination revealed that the boy was fairly well nourished and fairly well built except for a round shoulder deformity. There was a congenital bilateral absence of the pectoralis major and minor muscles, more pronounced on the left side. His feet were well

formed and presented no abnormalities. The second toes were slightly longer than the big toes, as in average normal feet. No roentgenogram of the feet was taken.

Examination of the hands revealed they were of the long and rather narrow type, and in a relaxed attitude, both hands were held in slight radial deviation at the wrist joints (Fig 8).

Roentgenogram (Fig 4) of the wrists showed that the lower end of the ulna extended slightly more distally than that of the radius, unlike the reverse

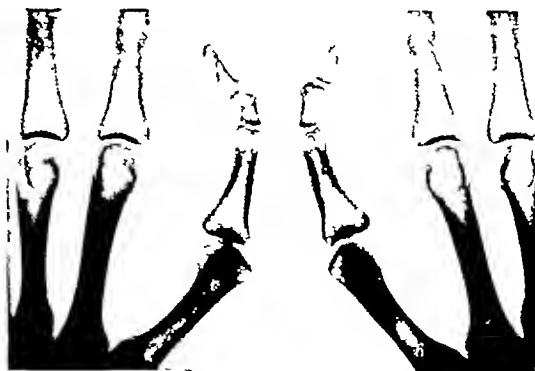


Fig 3 Case 2 Dorsopalmar view of both hands with the thumbs—a, left, b, right—shown in oblique view. Note the excessive length of both thumbs which reach almost to the level of the proximal interphalangeal joint of the index. Note also the ulnar deviation of the nail phalanx of both thumbs with trapezoid shaped middle phalanges, especially on the left side. The middle phalanx of the right thumb is larger, with its articular surfaces more parallel to each other, and it appears more like a normal phalanx.

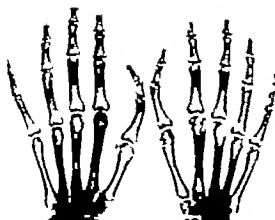


Fig. 4. Case 3. Dorsopalmar view of both hands a, left b, right. Note the trapezoid shaped appearance of the middle phalanx (especially on the left) with radial deviation of the distal part of the triphalangeal thumbs. Note also that the second metacarpal head extends more distally than the third. Likewise, the ulnar styloid is more distal than the radial styloid.

relationship in a normal adult human wrist. This was somewhat more marked on the right side and apparently was responsible for the radial deviation of the hands. The carpal bones appeared to be essentially normal.

The thumbs were unusually long, especially the right. The tip of the right thumb reached to the level of the distal interphalangeal joint of the index finger while that of the left thumb reached to the proximal interphalangeal joint of the index. The distal triphalanges of both thumbs were held in slight palmar flexion and also were deviated ulnarward, pointing to the index finger. This was more pronounced on the left side. Both thumb eminences were much flatter and longer than normal.

True opposition of both thumbs as tested so that the palmar surface of the tip of the thumb could be placed parallel to the palmar surface of the lesser fingers, both of these planes forming an angle of 90 degrees in full opposition. The prevailing motion of both thumbs was that of palmar flexion, produced by the flexor pollicis longus.

The web between the first and second fingers as located much more distally than in a normal hand, being almost at the level of the metacarpophalangeal joint of the index on the right side and slightly proximal to it on the left side.

The range of motion of both wrists and fingers was similar on both sides. The metacarpophalangeal joint of the thumbs could be hyperextended to 35 degrees beyond neutral and palmar flexed to an angle of 90 degrees. The proximal interphalangeal joints of both thumbs were fixed in palmar flexion of 65 degrees and could be further palmar flexed to 50 degrees. The distal interphalangeal joint as the least movable motion being



Fig. 5. Case 4. Dorsopalmar view of both thumbs a, left b, right—illustration especially the trapezoid shape of the middle phalanx with ulnar deviation of the distal part of the thumb, more marked on the left side.

possible between 80 and 4 degrees. There is definite limitation of palmar flexion at the second, third and fourth metacarpophalangeal joints, especially at the second. Hyperextension at the metacarpophalangeal joints of the index, third, fourth, and fifth fingers as possible to 30 degrees, 20 degrees, degrees, and 5 degrees beyond neutral, respectively. Palmar flexion in these joints listed in the same order as possible to an angle: 50 degrees, degrees, 20 degrees, and 85 degrees, respectively. The range of motion at the proximal and the distal interphalangeal joints of the lesser fingers was normal except for a few degrees of limitation of dorsiflexion at the proximal interphalangeal joint of all the lesser fingers.

The right radial pulse as not felt in its usual location but could be palpated along the middle line on the palmar aspect of the forearm just below the wrist. On the left side the pulse present in its normal location.

The roentgenogram of both hands on dorsopalmar view (Fig. 4) showed that the right first metacarpus was considerably longer than the left, being most responsible for the comparatively increased length of the right thumb. It is interesting to note that the second metacarpal heads extended farther distally than the third, not as is found in an average human hand. The tip of the third digit as the longest of both hands 5 centimeter longer than the index.

Both thumbs had three well formed phalanges. The nail and the proximal phalanx presented no definite abnormalities. Likewise the middle phalanx of the right thumb as somewhat similar in its size and shape to that of the fifth finger. The middle phalanx of the left thumb, however, was definitely trapezoid shaped and as somewhat shorter and stouter than that on the right. Slight palmar flexion and radial deviation of the distal part of the thumb were evident. The trapezoid shape of the middle phalanx of the left thumb and ulnar deviation of the distal part of both thumbs were especially demonstrated on dorsopalmar view of the thumb (Fig. 5).

CASE 4. G. H. Hite male aged 5 years father of J. G. as paper cutter by trade and as a

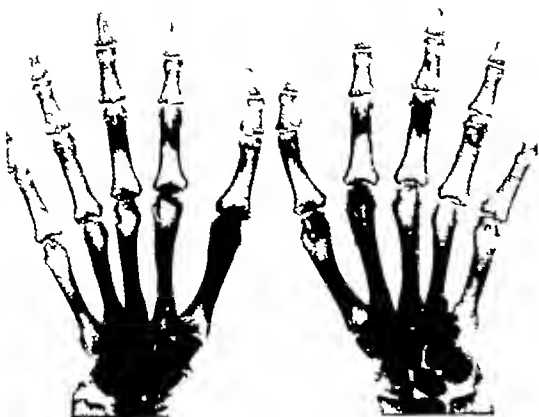


Fig 6 Case 4 Dorsopalmar view of both hands, with similar findings as described in Figure 4. Note that the second metacarpal head extends somewhat more distally than the third, especially on the left side. The relatively greater length of the styloid of the ulna is more marked than in Case 3. In addition, there are bilateral bipartite navicular bones (not a fracture). Slight productive osteoarthritic changes are present between the left navicular and multangulum majus on the left side.

handicapped by the anomaly of triphalangism of his thumbs. He stated definitely that none of his four brothers and three sisters, nor his father and mother and both grandparents had any abnormalities of their hands and feet. J. G., his son, was the only other member of his family having triphalangeal thumbs. The one brother of J. G. had normal hands and feet.

At the age of 12, I. G. gradually developed considerable scoliosis. Prior to this age his back was said to be perfectly straight.

Examination revealed a small, elderly man with very marked right dorsal scoliosis. There was considerable asymmetry of the chest, the left ribs being more prominent anteriorly than the right. This was apparently related to the scoliosis and was not congenital. There was complete bilateral absence of the pectoralis major and minor muscles. The feet were essentially negative, except for bilateral absence of pulsation of the posterior tibial arteries, which was apparently an anatomical variation and not an arterial occlusion.

Both hands of I. G. presented essentially the same appearance as those of his son (Fig 9). Both thumbs were triphalangeal, and the thenar eminences were poorly developed. The tips of the thumbs reached to the level of the distal interphalangeal joint of the index fingers. Both thumbs were of about the same length, except that the left appeared to be a few millimeters longer.

The web between the first and second fingers was at the level of the metacarpophalangeal joint of the thumbs.

The range of motion of the right and left thumbs was similar. Dorsiflexion at the first metacarpophalangeal joint was possible to 10 degrees beyond

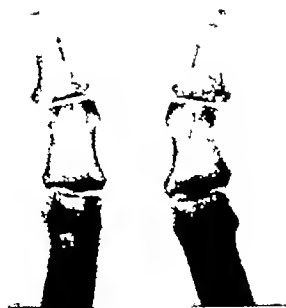


Fig 7 Case 4 Dorsopalmar view of both thumbs, showing moderately trapezoid shaped middle phalanx with radial deviation of the distal part of the thumb.

neutral and palmar flexion to 90 degrees. The proximal interphalangeal joints could be dorsiflexed to 5 degrees beyond neutral and palmar flexed to an angle of 80 degrees. At the distal interphalangeal joint motion was possible from 180 to 160 degrees of palmar flexion.

Active opposition of the thumbs was lost the same as in the son's hands. The father's hands, like the son's, also presented some restriction of palmar flexion at the metacarpophalangeal joints of the lesser fingers. The metacarpophalangeal joints of the second, third, fourth, and fifth fingers each could be dorsiflexed to 10 degrees beyond neutral and palmar flexed to 100 degrees, 90 degrees, 90 degrees, and 85 degrees, respectively. The motion of the interphalangeal joints of the lesser fingers was normal.

No arterial pulse could be palpated anywhere on the palmar or dorsal aspect of either wrist or lower third of forearms.

A roentgenogram of both hands on dorsopalmar view (Fig 6) showed that both thumbs had three phalanges. The proximal and the nail phalanges of both thumbs resembled those of the lesser fingers. The middle phalanx, however, was much stouter and somewhat shorter than the middle phalanges of the lesser fingers. It also differed from them because of its slight trapezoid shape. These special features of the middle phalanx of the thumbs were especially evident on dorsopalmar view of the thumbs (Fig 7), which also showed slight ulnar deviation of the nail phalanx (although not as marked as on the left thumb of the son).

Both first metacarpals were about the same length. The second and third metacarpal heads of the right hand appeared to extend distally to about the same level. The left second metacarpal head extended about 2 millimeters more distally than the right. However, both third fingers were the longest. Roentgenogram of the wrists (Fig 6) showed marked development of the styloid of the ulna, which was longer than that of the radius, the styloid process of



Fig. 8.

Fig. 8. Case 3. Photograph of hands.



Fig. 9.

Fig. 9. Case 4. Photograph of hands.



Fig. 10.

Fig. 10. Case 5, R. G. Photograph of both hands showing bidd left thumb.

Fig. 10. Case 5, R. G. Photograph of both hands showing bidd left thumb. The left ulnar thumb has normal appearance and has two phalanges. The left radial thumb is smaller and is triphalangeal.

the latter appearing somewhat underdeveloped. All of these are even more pronounced in the father than in the son. In addition, both nascula bones were bipartite in the father.

CASE 5. R. G., white printer aged 21 years, was seen at the Induction Station. He had congenital deformity of the left thumb only. There was no history of any deformities of hands or feet in the known members of his family for three generations. In addition to the left thumb deformity he had draining pilonidal sinus. One of his brothers (so had a pilonidal sinus. The draftsman was well built, somewhat overweight, apparently healthy young man. His penis was underdeveloped. Likewise, both of his testicles were very small, the size of small grapes, although both of them were fully descended into the scrotum. He reported practically complete lack of sexual desire. Mentally he was normal. Both of his feet appeared to be perfectly normal except for mild pes planus (no roentgenograms of feet were taken).

The left thumb was bidd with two well developed nails (Fig. 8). There was skin web connecting the two thumbs almost down to the distal phalanx. The roentgenogram of both hands (Fig. 9) showed an apparently normal left first metacarpal, which articulated with the two basal phalanges spreading in V-shape manner. The basal phalanx of the ulnar thumb was of approximately normal size and shape and articulated with normal nail phalanx. The basal phalanx of the radial thumb was much shorter and slender than that of the ulnar thumb. It continued into the middle and nail phalanges in the radial thumb, both of which were rather small and thin. The middle phalanx of the radial thumb formed almost right angle with its basal phalanx. Well developed proximal and distal interphalangeal joints of the radial thumb are demonstrable. Otherwise the roentgenogram of the hands presented no abnormalities. The third metacarpal head on both sides extended slightly more distally than the corresponding second metacarpal head. The styloid of the ulna on both right and left sides extended slightly more distally than did the styloid of the radius.

Motion of the "compound" left first metacarpophalangeal joint was limited, being possible between 30 and 50 degrees of palmar flexion. The entire bidd thumb moving in the plane.

The same limited range of motion was also present in the right first metacarpophalangeal joint. Motion of the interphalangeal joints of both left thumbs, the two phalangeal, and the triphalangeal, was almost completely absent being reduced to a slight wobble. Opposition of the left thumb, mainly of its ulnar component, normal.

CASE 6. A white male aged 5 years, seen at the Induction Station. There was no history of any deformities in his family. He was well built, healthy young man and presented no abnormalities other than his left thumb. The latter very short and formed almost right angle with the long axis of the hand. Motion of the right thumb was somewhat restricted.

The roentgenogram of both hands (Fig. 10) shows that the left first metacarpal is only slightly shorter than the right. The nail phalanx of the left thumb was approximately of the same size and configuration as that of the right thumb. A short square ossicle, evidently the proximal phalanx of the thumb, articulated with the nail phalanx distally and with the radial part of the first metacarpal head, proximally. There was neither triangle-shaped ossicle articulating with the ulnar part of the first metacarpal head. This ossicle, as located just ulnarward to the distal two proximal phalanx, hugging the latter to its ulnar surface. Two sesamoid-like are present over the palmar aspect of the first metacarpal head of each thumb and radial sesamoid was present over each second metacarpal head. At first glance one had the impression that the left thumb had three phalanges. However, comparison of the left thumb of Case 6 with typical bidd thumb (Fig. 3) suggests entirely different interpretation.

Apparently the left thumb in Case 6 may also be known upon as a bidd thumb which the ulnar part of the radial thumb and the basal phalanx of the ulnar thumb form a triangle.

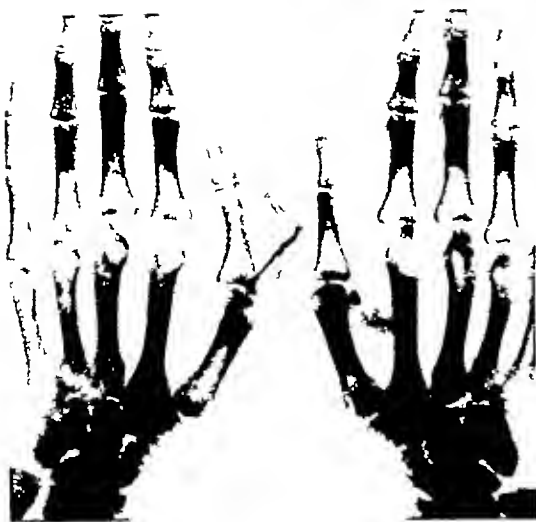


Fig. 11 Case 5 R G Roentgenogram of both hands showing triphalangeal left radial thumb, a, left. Note that the styloid of the ulna extends slightly more distally than that of the radius

gular ossicle) of the ulnar thumb have been retained, while the nail phalanx of the ulnar thumb has been lost. Case 6 bears a great similarity to Case 1, both apparently presenting atypical bifid thumbs, and not a triphalangism of the thumb. In Case 1, however, only the nail phalanx was bifid, while in Case 6 the division was more extensive so that both the nail and the proximal phalanx were bifid.<sup>1</sup>

#### ETIOLOGY AND ORIGIN OF TRIPHALANGISM

It is not within the scope of this paper to go into a detailed discussion and review of the extensive literature on the etiology and origin of triphalangism of the thumb. Numerous speculative hypotheses have been advanced, none of which seems to be sufficiently substantiated.

The theory of phylogenetic origin of triphalangism of the thumb seems to be the weakest.

According to Morton (1935), "the number of phalanges in ancient amphibian digits was quite variable but yielded a subsequent reptilian formula of 2, 3, 4, 5, 4. The phalangeal bones of the digits tended toward a re-

duction in the feet of some of the ancient reptiles, and, of particular significance, within the mammal-like therapsid group the phalanges were reduced to the characteristic mammalian formula of 2, 3, 3, 5, 3."

Even in the lowest scale of modern animal life, as amphibians, the two phalangeal formula of the first digit is firmly established. Therefore it seems to be too much of a stretch of the imagination to consider the triphalangeal thumb as a reversion to the more primitive condition.

Some regard the two phalangeal formula of the thumb as a result of disappearance of one of its phalanges. Others look upon the first metacarpal as a basal phalanx and assume that the thumb has lost its metacarpal bone. Galen (130-200 A.D.), quoted by Mueller (1937) was one of the earliest proponents of the latter view.

The peculiarity of the epiphysis of the first metacarpal, which, as a rule, develops only at its base, similarly to the epiphyses of the phalanges, seems to afford some support to the consideration of the first metacarpal as a phalanx. However, this concept is undermined by the existence of numerous cases with a capital epiphysis present in addition to the basal epiphysis at the first metacarpal.

Regardless of whether the first metacarpal is considered a true metacarpal or a basal phalanx, both of these views are untenable as



Fig. 12 Case 6 Evidently a bifid right thumb, simulating triphalangism. The punctate outline reconstructs the part of the basal phalanx and the nail phalanx of the right ulnar thumb which probably have failed to develop.

<sup>1</sup>Later the authors expect to publish their observations in a number of cases of bifid thumbs of varied extent of division. It is their opinion that this anomaly is not a rarity.





Fig. 3. Dorsopalmar roentgenogram of right bifid thumb. 1/3 division extending through the nail and proximal phalanges.

explanations for triphalangism of the thumb since the two phalangeal formula (two phalanges and a metacarpal or three phalanges with out a metacarpal) is constant in the first digit of all forms of animal life from the amphibians up.

It is difficult to conceive of the presence of the third phalanx as resulting from lack of fusion of the epiphysis of one of the phalanges of the thumb since there are true joints separating the middle phalanx from the other two phalanges in a triphalangeal thumb. There is no known instance of formation within epiphyseal cartilage of a true joint with articular facets lined with hyaline cartilage and a joint capsule.

In addition, the lack of evidence for triphalangism of the thumb both in early embryonal development and in fossil specimens of higher vertebrates also speaks against these two theories.

Joachimsthal (1900) advanced the belief that some instances of triphalangeal thumb represented a duplication of the index finger with absence of the thumb. Similarly Graefenberg (1914) postulated that the hand with a triphalangeal digit on the radial side of the four lesser fingers should be interpreted as one with the thumb absent and with a part of another hand added instead of the lost thumb.

These interpretations may perhaps be applicable only in those comparatively few recorded cases (see Figs. 4 and 5, Case 2 Cohn 1932) in which there was no evidence of the usual characteristics of the thumb such as the well developed specialized musculature of the thenar eminence. However it appears that cases of true thumbs with three phalanges as are the majority of cases recorded in the literature including the 6 reported here can hardly be explained by these theories.

To account for the presence of fully developed thumbs with three phalanges the possibility of some congenital or hereditary disorientation of the germ plasm, as advanced by some writers seems a more plausible postulation, although evidence is lacking to make it conclusive.

Haas (1939) in a study of three families, made the interesting observation of longitudinal splitting of the distal part of the nail phalanx, giving it a peculiar "duck bill" appearance. A similar "duck-bill" appearance of the right thumb is present in Case 3 (Fig. 6) of Cohn's (1932) series. In none of the cases reported here was the "duck-bill" division of the nail phalanx present.

Haas states "The explanation offered for this anomaly of a three-phalangeal thumb is that it may be an arrested attempt to form an extra thumb. It seems to the authors that the "duck-bill" appearance should be interpreted rather as a tendency toward the formation of a bifid thumb (Figs. 10 11 13).

Cases of bifid digits or longitudinal division of the digital rays, including the thumb leading to their duplication are well known (Fig. 13). The extent of this division varies from slight longitudinal splitting of the distal part of the nail phalanx ("duck-bill" appearance described by Haas) to actual presence of two separate nail phalanges or even complete duplication of the entire digit including the metacarpal. The two members are then in the same relation to each other as the object to its mirror image (Fig. 13).

Figures 1 and 12 showing a dorsopalmar view of the left thumb of Case 1 and that of Case 6 are suggestive. In Case 1 (Fig. 1) the punctate outline reconstructs the absent distal part of the nail phalanx of a bifid thumb, only the

base of which is present and simulates a middle phalanx of the thumb. In Case 6 (Fig. 12) the pincerlike outline represents the missing parts of the proximal and nail phalanges. Note that in Cases 2, 3, and 4 (Figs. 3, 5, and 7) and also in cases reported by numerous other observers, both middle phalanges appear wedge shaped or more or less trapezoid shaped. It is possible to assume that in Cases 2, 3, and 4 the middle phalanx also represents a part of the base of an additional nail phalanx. This base, however, became completely interposed between the nail and the basal phalanges of the thumb and therefore lost its wedge shaped appearance, as in Cases 1 and 6, as a more trapezoid shape at first. The middle phalanx of the right thumb in Cases 2, 3, and 4 (Figs. 3, 5, and 7) seems to illustrate a further step in the same process. The middle phalanx became eliminated, with its two articular surfaces becoming more parallel to each other and appearing more like a normal phalanx. The dorso palmar view of the thumbs in Case 1, the left thumb in Case 3, and the right thumb in the same case may be considered as representing different stages in this metamorphosis of the middle phalanx from a wedge shaped one (Fig. 1) through the markedly trapezoid shape (Fig. 5, left thumb) and finally to an almost normal appearing phalanx (Fig. 5, right thumb).

The almost constantly present ulnar deviation of the distal part of the triphalangial thumb may also be interpreted as favoring the above theory. It can be assumed that the distal part of the radial member in a bifid thumb was lost while the ulnar member remained, retaining its original ulnar and pointing position. In Case 6 (Fig. 12) apparently the radial member of a bifid thumb was retained while only a part of the basal phalanx of the ulnar thumb remained.

The hereditary tendency in the occurrence of congenital anomalies of the limbs including triphalangism of the thumb is a well established fact, noted in a majority of the recorded cases and illustrated by 3 of our cases (Cases 2, 3, 4).

The frequency of the occurrence of a combination of triphalangial thumb with a bifid thumb (Figs. 10, 11) and also with various

other congenital malformations in the same individual or in different members of the same family has also been confirmed by numerous observers. In Cases 3 and 4 the triphalangism of the thumbs was associated with bilateral congenital absence of the pectoral muscles.

The congenital division of both carpal navicular bone in Case 4 seems to be a similar feature, since the navicular bone (os naviculare) and os centrale is normally bipartite in a number of lower primates (Taphus 1930, Fig. 3). Likewise the greater length of the distal styloid as compared with the radius also seems to be a similar characteristic.

Mueller (1936) collected 5 cases of triphalangial thumb. In all of the cases there was also evidence of bifid thumb (one of the cases even presented the extremely rare anomaly of bilateral triad division of the nail phalanx, in addition to triphalangism of the thumbs).

In 2 of Mueller's cases definite heredity of the anomaly could be established for four and five generations respectively. In 1 case inquiry revealed that none of the relatives had any malformations. In the 2 remaining cases no family history was obtainable.

Most interesting is Case 3 in Mueller's series, where the paternal great grandmother and grandmother had simple triphalangism of the thumb and the patient and his father had a combination of triphalangism of the thumb with bifid thumb. In Case 5 triphalangism of the thumb on both hands was associated with doubling of the thumbs and congenital webbing of all the lesser fingers of both hands. A complete family tree for five generations showed the occurrence of triphalangial thumbs in various combinations with radial polydactylism (double thumbs), syndactylism of the fingers and toes, congenital shortening of the index finger and congenital shortening of the fifth fingers with hemidactylism (congenital lateral deviation of the distal part of the finger) in different members of the family.

The frequent association of triphalangism of the thumb with bifid thumb (longitudinal splitting into two symmetrical parts) seems to furnish additional evidence stressing their close relationship. Consequently, it is possible that triphalangism of the thumb may be only an incomplete development of the distal part

of one of the two nail phalanges of a bifid thumb (Figs. 1 12 13)

If this theory is correct then the middle phalanx of the triphalangeal thumb cannot be considered as a true middle phalanx homologous to the middle phalanx of the lesser fingers. It must be looked upon rather as a remnant of the base of an accessory nail or proximal phalanx which failed to achieve full development.

#### SUMMARY

1 Six cases of triphalangeal thumb have been reported. In 3 of these heredity of the anomaly could be established.

2 This anomaly must be considered rare since the first 3 cases were noted among more than 75,000 draftees examined.

3 None of the various theories advanced at present can be accepted as an adequate explanation for the cause of this anomaly.

4 From a review of the recorded cases including the 6 cases reported here it appears that triphalangism of the thumb may have at least two origins. (a) Double index or an extra finger fused on the radial side of the hand

which lost its thumb simulating the triphalangeal thumb. (b) Remnant of one of the phalanges of an incompletely developed hind thumb simulating a third phalanx.

5 If these two theories are correct, it follows therefore that in the first the triphalangeal digit is not a true thumb. According to the second theory the additional phalanx is not a true middle phalanx similar to that of the lesser fingers, but a remnant of the base of one of the phalanges of a bifid thumb. The latter theory is favored by the authors.

#### REFERENCES

- Conry, J. *Radiology* 912, 8 59
1. R. J. M. South M. J. 910, 3 536
2. GRANT-REID, *Stud. Path. Eritr.* 944, 345.
3. H. S. L. Ann. J. Roentg. 930, 4 677
4. J. SCHNEIDER, G. Berl. klin. Woch. 950, 5 215
5. K. M. A. B. Arch. Surg. 93 5 9
6. LUNDY, P. W. J. Bone Joint. 940, 1093
7. MONTGOMERY, D. J. *The Human Hand*, Pp. 4, 30 New York, Columbia University Press, 935.
8. MULLER, W. Arch. klin. Chir. 936, 85 377
9. Idem. *Die angeborenen Fehlbildungen der menschlichen Hand* Erbsund Konstitutionslehre der Hand. Leipzig, Georg Thieme 937
10. SMITH, H. *Ueber Hyperphalangie des Daumens* Anat. Anz. 9 3-9 6, 4 565

# INSERTION OF SMITH-PIETERSEN NAIL WITHOUT AN INITIAL SKIN INCISION

BERNARD B. FALKS, M.D., F.A.C.S., Cleveland, Ohio

There is evidence that intracapsular hip fractures are not so prevalent. The Smith-Petersen type of nail probably is the most reliable method of fixation as it is stable and stable after to the excellent results obtained.

For technique in inserting this type of nail has been described by several experienced hip surgeons. The technique is described by the author in the following. The first step is to make a skin incision over the greater trochanter. The Smith-Petersen nail is then inserted into the fracture site. The nail is then secured by the use of the staples and the fracture is fixed.

A number of guide lines have been developed to simplify the insertion of the nail. Several are based on the fact that the anterior border of the femoral head and neck are normally parallel with the center of the femoral head. Examples of these are the Huley guide, the L. J. guide, the S. J. guide, the P. J. guide, and the G. J. guide. The latter guide is for the insertion of the nail and the guide described here is a guide to the insertion of the nail in the use of the Smith-Petersen nail.

This procedure may be done with or without fluoroscopic control. If fluoroscopic control is the method of choice, one must be sure that there is sufficient power available in the machine and an acceptable table to give good visualization. Lateral check-up roentgenograms after reduction are also essential because of the inadequacy of the fluoroscope for this view.

The patient is placed on a cassette tunnel to facilitate the sliding of the cassette into place for the anteroposterior roentgenogram. This tunnel also raises the patient so that the lateral roentgenogram is more easily taken. The lateral view is taken by holding the x-ray plate at an angle away from the crest of the ilium as has been frequently described.

We prefer spinal anesthesia of about 30 to 50 milligrams of novocain crystals or its equivalent

to this particular procedure. In old people this is an adequate dose if given correctly. This small dose seldom causes any marked drop in blood pressure. The period of anesthesia is short but long enough for this operation. The relaxation obtained is ideal.

We reduce the fractured hip by the following technique and take an anteroposterior and a lateral roentgenogram to make certain the reduction is good. Complete anatomical reduction of intracapsular fractures of the hip is most often easily accomplished and is practically always possible. Therefore the finding of an inadequately reduced hip is a common mistake indeed. After reduction the leg is held by an assistant throughout the procedure in marked internal rotation and moderate abduction. Usually the marked internal rotation of the extremity brings the neck of the femur into a plane parallel or closely parallel to the top of the operating table which helps to make the procedure technically easy.

While the check-up x-ray plates are being developed the site of operation is prepared with an antiseptic. A cloth wet with bichloride solution is then placed over the field and is left in place during the entire procedure. This gives added protection against infection. The usual draping is done after this cloth is in place.

If the check-up roentgenograms show good reduction we are ready to proceed with the operation. We use a simple instrument consisting of a Steinmann pin, a block of steel with parallel holes drilled through it, and a small caliber trochar. The block of steel has three parallel holes bored through it, one the diameter of the trochar and two the diameter of our Steinmann pin. The center of the latter two holes are  $\frac{1}{8}$  of an inch and  $\frac{1}{16}$  of an inch from the center of the hole having the diameter of the trochar. In cases of extra large bones we use the holes farthest apart, in all other cases the holes closer together are used.

We place a towel clip deeply into the antero-lateral aspect of the thigh and with strong traction pull the belly of the vastus lateralis muscle forward. This makes the shift of the femur just distal to the trochanter, which is the optimum

From the Department of Surgery, of Western Reserve University School of Medicine and the Fracture Service of Cleveland City Hospital. Presented as a moving picture at the meeting of the Central Surgical Association, Chicago, February, 1942.  
Cleveland, F. O., and Tuttle, A. Surg. Gyn. Obst., 1942, 72: 106-111.

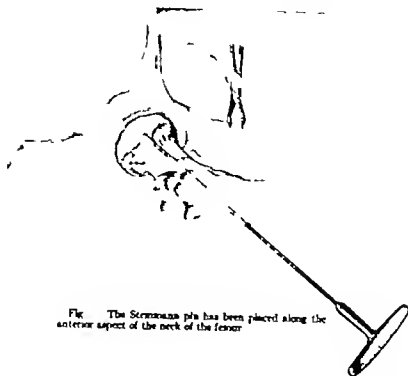


Fig. The Semmings pin has been placed along the anterior aspect of the neck of the lesser



Fig. The guide block and trochar are in place. Note that the trochar is directly posterior to the Semmings pin.

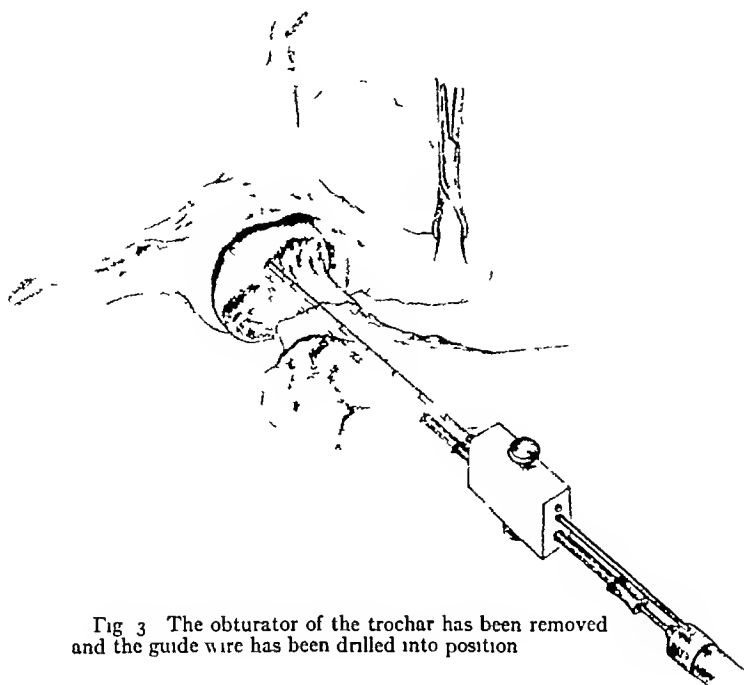


Fig 3 The obturator of the trochar has been removed and the guide wire has been drilled into position



Fig 4 The instrument has been removed and the guide wire for the Smith Petersen nail is in place

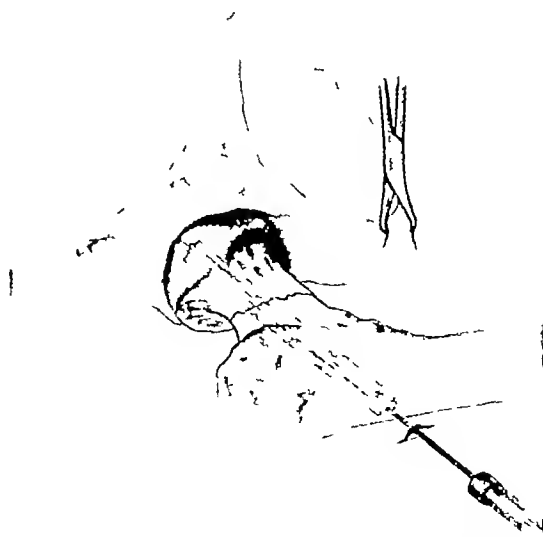


Fig 5 The Smith Petersen nail is shown in proper position

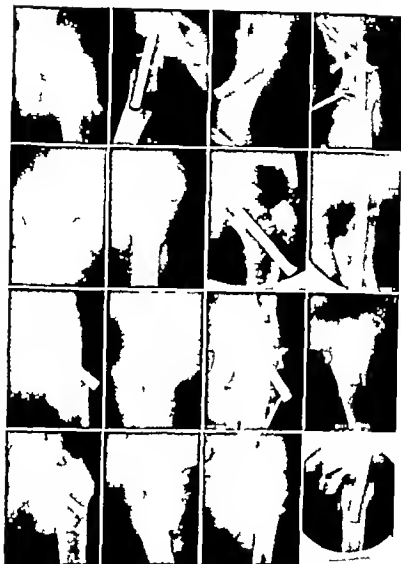


Fig. 6. Immediate results in the first 6 cases. Approximately to cases has also been done with equally good results.

location for the nail, more easily palpable, and also presents an almost avascular area through which to operate.

The Steinmann pin, used as a probe, is thrust through the skin and along the middle of the anterior portion of the neck of the femur (Fig. 1). A chuck handle is used to make the handling of the pin more easy. If the pin depresses to either side of the neck, this can be felt as can also the solid bone if the pin is properly inserted. The

point of the Steinmann pin is pushed hard against the head of the femur when its resistance is met. Fluoroscopic visualization of this entire procedure makes it extremely simple. If the operation is being done blindly an anteroposterior roentgenogram is taken at this point to be sure that this important guide (the Steinmann pin) has been properly placed. This Steinmann pin is grooved each half inch so that the length of Smith-Petersen nail which will later be required

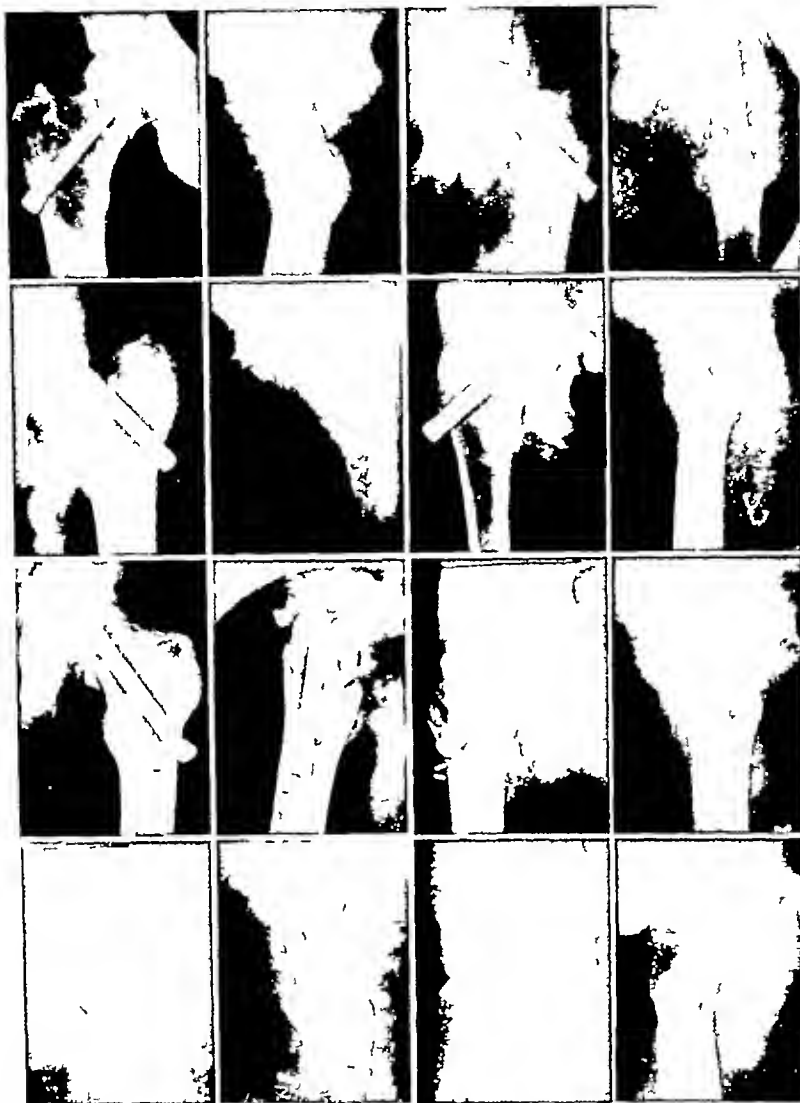


Fig 6—Continued

can be computed easily on examination of the roentgenogram

The steel guide block is now threaded on the Steinmann pin up to the skin and is so placed that the hole for the trochar lies directly posterior. The trochar is placed through this hole and thrust through the skin and hard against the shaft of the femur (Fig 2). The obturator of the trochar is hit sharply so as to dent the hard femoral shaft, after this has been done the obturator of the trochar is removed.

A guide wire for the Smith-Petersen nail, which is  $10\frac{1}{2}$  inches in length and  $\frac{3}{32}$  of an inch in diameter, is now threaded through the trochar and is drilled into place if the fluoroscope is being used. When fluoroscopic control is not being used, we usually drill the wire in about 2 inches and then pound it into its proper position (Fig 3). The density of the femoral head can thus be detected, regulating the distance the guide wire is inserted. The guide instrument is now removed leaving the guide wire for the Smith-Petersen nail.



in proper position in the neck of the femur (Fig. 4). If the foregoing operative technique has been properly carried out this wire is bound to be in good position.

If the fluoroscope has been used, the Smith-Petersen nail to be used is determined by placing another  $0\frac{1}{4}$  inch wire alongside the inserted guide wire with the tip against the shaft of the femur. The difference in the apparent length of the two wires is the proper length of nail to be used.

A small skin incision is made along the guide wire, just large enough to admit the Smith-Petersen nail, which is threaded over the guide wire and driven home (Fig. 5). There is no bleeding. The guide wire is removed and the skin incision is closed with a single skin clip to complete the procedure.

The actual operating time is only a matter of minutes. With this method the position of the

guide wire for the Smith-Petersen nail in the anteroposterior plane is practically certain and its position in the longitudinal plane if the fluoroscope is used, is absolutely under the operator's visual control.

#### SUMMARY

The small amount of anesthesia required, the shortness of the procedure, and the absence of loss of blood all decrease the possibility of shock in these patients who are usually old. The danger of infection when this technique is used is minimal. These factors plus the extreme ease with which this simple procedure is carried out, recommend it for use in either the completely equipped institution where fluoroscopic control can easily be used, or in those institutions where only a small portable x-ray machine is available.

The procedure described has been carried out in more than 60 cases with entirely satisfactory results (Fig. 6).





Fig. 1. a, left, Typical arterial angoma appearing during first weeks of life and growing steadily until its present stage at the age of 6 months. The tip of the nose is involved. It is considerably more depth of tumor than is evident in the photograph. The mucous membrane of the underlying septum and the columella were also involved. Treatment was by interstitial implantation of 5 gold seeds, each containing 3 milligrams of radon. b, The single treatment sufficed for cure as is shown in the picture taken at the age of 5 years. There is no gross abnormality of the skin and the growth of the nasal cartilages and bone has progressed normally.



b

Fig. 2. a, Six months old child admitted to the hospital in critical condition due to respiratory obstruction as a result of extreme involvement of deep neck and peritracheal structures with arterial angoma. This had appeared shortly after birth and grown rapidly despite feeble efforts to control it with carbon dioxide snow. The nose was treated with interstitial implantation of 35 gold seeds, each containing 3/4 milligram of radon to the neck area from trachea on the left to just back of the ear on the opposite

side. Within 3 days, the child was free from respiratory embarrassment. Three months later, 35 seeds, each containing 3/4 milligram of radon, were implanted in the scalp, cheek and ear areas. Three months later, 35 seeds, each containing 3/4 milligram of radon, were implanted here and there about areas of activity b and c. Result 4 years later. There is considerable scarring of the skin, principally the result of the tumor. A 3/4 inch plica down the left side of the back of the neck has been relieved by the interdigitation of flaps. There is no evidence of angoma.





Fig. 5 a, left, Arterial angioma occurring on the lower eyelid of an infant and reaching its present size in 8 weeks. If uncontrolled, this could soon involve the conjunctiva and could even threaten the eye itself (see Fig. 3). Surgical excision could be done, but this would necessitate replacement of skin and could definitely have damaged the musculature of the lower eyelid. The accurate application of surface radium could be difficult as it could be the treatment with carbon dioxide snow. This was treated by the interstitial implantation of 2 gold seeds, each containing 5 millicurie of radon. b, The child is shown 6 months after treatment. This is a good result from the standpoint of selective dosages. There has been control of the tumor without damage to the surrounding tissues and progressive fading of the "birth mark." It is expected that the slight discoloration of the skin still present will improve further with time.



Fig. 6 a, left, Arterial hemangioma of the rapidly growing type which was approaching the biliary structures. Spontaneous ulceration is present. Surgical removal would be difficult from the standpoint of closing the wound. This is one of our earlier cases in which radon was employed. b, The result 4 years after treatment. There is ulceration of the wound resulting in poor cosmetic appearance in the center of the area. This is the result of improper distribution of the seeds and overirradiation of the center of the wound. Treatment was 10 gold seeds, each containing 5 millicurie of radon. On the basis of subsequent experience it could have been better to have used seed of 5 millicurie content, getting more equal distribution of the seeds and repeating this treatment if necessary at any point. The dark areas are not angioma but permeation of the scar. Function is normal.

portance in eradicating deep growths with minimum damage to the skin and without endangering other important structures—

#### TECHNIQUE OF TREATMENT

Anesthesia may be general or local depending on the size and location of the growth and the age and condition of the patient. For the introduction of the radon which is contained in a tiny gold seed, a hollow needle fitted with a plunger for the expulsion of the seed is used. The success of the treatment depends on getting adequate and equal radiation to all portions of the growth. Multiple introducers are used—oftentimes making a separate puncture of entrance for each introducer. For a small growth all points of deposit of the radon seeds may be reached through a single puncture. The gold seeds containing a known amount of radon, are introduced where desired in effort being made to estimate the point of deposit to obtain a uniform distribution of seeds not neglecting any ramification of the tumor, and allowing an equal amount of tumor to each seed. Hemorrhage is not severe and can be controlled by a few moments of pressure, or a pressure bandage may be applied for 24 hours.

**Dosage.** A fairly small dosage of radiation per unit of volume of tumor is required, but this radiation should be uniform throughout the tumor, and especially the deepest ramifications must be adequately radiated. The skin and the mucous membranes should be protected from overexposure. Thus the insertion of the seed directly under either of these structures is to be avoided when possible. If this is impossible, as in the eyelid or nose of the infant, then the millicurie content of each seed must be small. The possibility of damage to the cornea or lens of the eye and to growing bone and cartilage must be constantly kept in mind (Fig. 3). Estimation of the proper dosage and the difficulty in getting uniform distribution of the seeds in the tumor are the weakest points in this plan of treatment. Caution is necessary in calculating the dosage, and it is highly desirable that overirradiation be avoided even if some areas of the tumor may need a second treatment. It is desirable to gain control of the tumor with the least amount of radiation possible to get the best cosmetic result as well as to avoid damage to adjacent structures.

In treating cancer, frequently gold seeds containing 1, 1.5, or even higher millicurie content are used. In dealing with hemangiomas, most frequently seeds of 0.25 millicurie should be employed. Especially is this true about the eyes, nose, or other delicate tissues. When there is a

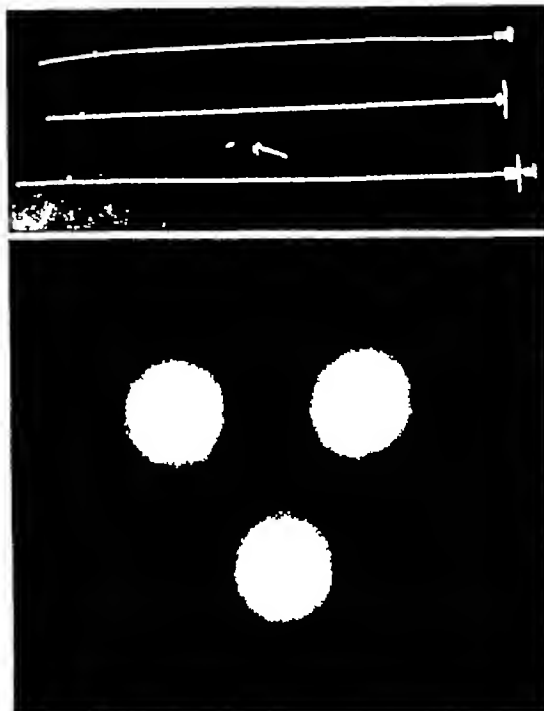


Fig. 7 a, above, Radon introducers and radon seed. The upper wire is a stylet removed from its needle directly under it. The bottom instrument is the complete introducer, the stylet being in position within the needle. The arrow points to a radon seed. This is made of gold and has walls 0.3 millimeter in thickness. Its length is 4 millimeters. b, below, Print from x-ray film exposed to 3 radon seeds 4 centimeters apart. The sphere of maximum effect of each seed is thus represented. Seeds should be implanted interstitially to allot each seed approximately this bulk of anaplastic tissue.

greater volume of ingrowth and delicate organs are not involved, the content of each seed may be 0.50 millicurie.

In general, the total dosage may be calculated as one radon seed per cubic centimeter of tissue to be radiated, the radon content of each seed to be as described previously. For flat lesions of no great depth, as can occur on the eyelid, it may be necessary to employ one seed to each square centimeter.

#### COMPLICATIONS

1. *Ulceration of the tumor.* In larger, rapidly growing, arterial angiomas, ulceration appears spontaneously without treatment or undue trauma in many cases (Figs. 4, 6). This indicates a lack of vitality of the tissues. Any form of treatment, with the exception of total excision, is likely to add to this ulceration before healing occurs. Infection within the tumor mass with the

formation of multiple infected thrombi is always a possibility. This has occurred in only one case. The percentage of incidence of this complication is low. It is not thought to be any higher with the use of interstitial radiation than with any other type of treatment, exclusive of the total removal of the growth.

2. *Secondary deformity.* The cosmetic result will largely depend on the amount of damage that has been done to the surface structures by the presence of the tumor itself (Fig. 1). If due caution is observed in selecting the dosage, damage to the cornea or lens, cessation of growth of nasal cartilages and bone, undue loss of subcutaneous tissue or the development of a radiation dermatitis in later life is thought to be minimal.

3. *Recurrence.* Secondary treatment may be necessary if some portion of the tumor is not controlled at the original treatment. This may be with more interstitial radiation or in some instances combined methods are desirable. Small outlying spots may be excised or cauterized. Purely cutaneous areas may be treated by surface means.

4. *Late surgical repairs.* Surface repairs may be

necessary in some instances in which the presence of the growth itself has caused poor appearance of the skin. This is true if some sloughing of the tumor has occurred, involving a feature. If the scalp is involved, excisions of bald spots may be desired.

5. *Retention of the gold seeds.* The gold seeds which contained the radon are of course retained in the tissues. There is no surrounding tissue reaction to the gold. Although the seeds are very tiny they may occasionally be visible if placed directly under the skin of the eyelid. If so, they may later be removed.

#### RESPONSE TO TREATMENT

The more rapidly growing hemangioma responds more readily than does the slower growing one. Usually within a week's time there is a definite decrease in the blood flow through the tumor. A speedy recession of the growth is usually noted after 3 weeks. Ideally, progressive improvement should occur over a period of 6 months to a year in cases in which the minimum but adequate dosage has been used.

# THE MECHANISM OF JAUNDICE IN CANCER OF THE PANCREAS

NAOMI KAPLAN, M D , and ALFRED ANGRIST, M D , Jamaica, Long Island, New York

THE classical picture of painless progressive jaundice with dilatation of the gall bladder, the syndrome of "pancreaticobilaire" of Bard and Pic, and again emphasized by Courvoisier, remains more of an approximation than an exact description in most cases of cancer of the head of the pancreas. More often than not, there exists some variation in the picture. Frequently there is pain (Barron, Clute, Friedenwald, Ransom), occasionally the jaundice is intermittent and sometimes there is no jaundice at all. Cancer of the body or tail of the pancreas or of both is always considered by contrast to be associated only rarely with jaundice, the syndrome "pancreatico-solaire" of Chauffard, yet cases often have been encountered in which jaundice is present (Duff). Variations in the clinical picture may occasionally be produced by complicating biliary calculi, but this is not responsible for the deviation from the classical syndrome in most cases.

## NATURE OF STUDY AND INCIDENCE

The cases of cancer of the pancreas which came to autopsy at the Queens General Hospital during the 7 year period from July, 1935, to July, 1942, have been reviewed, with special consideration as to location of the primary tumor, involvement of the biliary duct structures, and the presence or absence of jaundice. Only physical factors of obstruction were considered, with no attention to biochemical mechanisms involved in jaundice. In all cases of jaundice, the biliary duct structures were carefully studied histologically to confirm involvement by tumor. The group comprised 39 cases of cancer of the pancreas. Those involving the head, with or without involvement of the rest of the organ, are considered under the general heading of cancer of the head. Those in which the head is not involved are grouped together as cancer of the body or tail or of both.

Of the 39 cases, 25, or 64 per cent, were in the head, and 14, or 36 per cent, were in the body or tail or both. Hick reports 46 per cent occurring in the body and tail, but most other series give a

From the Pathology Department of Queens General Hospital Jamaica Long Island New York.

Presented before The New York Pathological Society November 12 1942

higher figure for head involvement. Some of the series are from surgical rather than autopsy material, so that a lower incidence for body and tail origin of the tumors would be expected (Table I).

TABLE I

		Head	Body or tail or both
Duff	Autopsy	28+3	7+10
Grauer	Autopsy	15+11+3	3
Hick	Autopsy	22+4	23
Lahey	Surgical	38+4	1
Ransom	Both	60%	30%
Queens			
General hospital autopsy		25	14

The age incidence ranges from 17 to 75, with an average of 58 years. There was no significant variation between the individual subgroups segregated by location or complications. The 6th and 7th decades show the highest incidence, with 11 in each, or a total of 56 per cent, occurring in the 20 year period between 50 and 70 years of age. The sex incidence showed marked preponderance of males, a ratio of 26 to 13, or 2 to 1. This is well recognized, and was noted in all but one of the series reviewed in the literature (Barron, Duff, Franco, MacKinnon, Ransom, 23).

## CLINICAL AND PATHOLOGICAL DATA

The clinical picture showed marked variation. Weight loss, anorexia, and weakness were the most constant findings. Pain was present in 12, and noted as being absent in 8 cases of cancer of the head. It was present in 11 and absent in 3 cases of cancer of the body or tail or of both.

Of the 39 cases, 19 showed jaundice, and this represents the group selected for study in this presentation. Of the 25 cases of cancer of the head, 13 presented jaundice, including 1 case in which it was intermittent. Six of the 14 cases of cancer of the body or tail or of both had jaundice. In a comparable series, Duff lists 13 or 16 cases of carcinoma of the head, and 8 of 16 cases of carcinoma of the body or tail or of both, with icterus. He makes the point that jaundice is a much later manifestation in the cases originating in the body or tail or of both, often appearing only terminally. This was not borne out by the present series. With the exception of 2 cases originating in the head





Fig. 1. Direct extension of cancer of head of pancreas to common bile duct with annular stenosis and obstruction.



Fig. 2. Direct extension of cancer of head of pancreas to common bile duct with annular stenosis and obstruction.

and surviving 5 to 7 months respectively after the appearance of icterus, the duration of jaundice was comparable in both groups. Excluding these cases, the average duration of jaundice was 5 weeks in both groups. It ranged from 1 to 9 weeks in the group arising in the body and tail, and 1 to 9 weeks in the group with the primary tumor in the head.

When jaundice was present the correct diagnosis was made clinically before operation in 4 cases, and was considered a possible diagnosis in 5 additional cases of cancer of the head, and in 1 case of cancer of the body and tail. However in the absence of jaundice the diagnosis of cancer of the pancreas was almost invariably missed; thus, as in other series (Humes, Adams, Duff). The reason for the difficulty in diagnosis of these cases is readily understandable. The pri-

mary tumor, whether located in the head or body or tail, does not of itself produce symptoms. The neoplasm is deeply placed and is undetectable by ordinary means of external or internal examination. It is only when the biliary tract is affected secondarily that recognizable symptomatology usually appears. When this involvement of the biliary ducts does not occur then ordinarily it is the spread of the tumor that leads to its detection. The first symptoms are then usually referable to some other part of the gastrointestinal tract, to some distant metastasis, or to the generalized carcinomatous. Cancer of the pancreas is one of the most common latent forms of malignant tumor.

Cancer of the pancreas spreads by direct extension, by lymphatics, by blood stream and by peritoneal implantation. Direct spread may lead to invasion of neighboring hollow organs and the spleen. There was invasion of the stomach in 6 of our cases, of the duodenum in 9, and of the transverse colon in 1. Obstruction of the gastrointestinal tract followed in 5 instances, and alteration and hemorrhage occurred in 6 cases. The bleeding in the latter group occurred usually late in the gastrointestinal tract, but in 2 cases it was into the peritoneal cavity. Lymphatic spread led to

invariable involvement of the regional lymph nodes and often further involvement of the retroperitoneal, periaortic, hypogastric, mesenteric, and mediastinal nodes. Hematogenous spread led to the involvement of the liver in 25 cases, the lungs in 10, the kidney in 3, the adrenal in 5, and the ovary in 1 case. The figures for brain and bone metastasis are incomplete. The liver may be reached by lymphatic as well as hematogenous routes and the resulting occasional picture of widespread lymphatic permeation about the duct structures is rather characteristic of pancreatic tumor origin. In most instances, the liver metastases were small, but in 2 cases they were massive. Peritoneal carcinomatosis was present in 12 of the cases.

Duff claims that cancer of the body and tail are more apt to give rise to widespread metastases because of anatomic factors which facilitate the spread from this region, i.e., the more extensive peritoneal surface, the more generous lymphatic supply, particularly the lymphatics along the nerve bundles of the celiac plexus, and the presence of the large splenic vein as an avenue for hematogenous spread. This explanation seems hardly necessary in view of the fact that cancer of the body and tail produces a biliary obstruction less often, which complication is apt to lead to the death of the patient before widespread dissemination has had a chance to take place.

Pancreatic tumors may be of duct, acinar or islet tissue origin. In this series, the histology of the tumor suggested duct origin in 24 instances, acinar in 13, and both types of histological structure were present in 2 cases. The cases which produced jaundice showed a higher percentage of duct adenocarcinoma than those in which there was no jaundice present. Scirrhus reaction was noted in all but one of the adenocarcinomas, whereas the tumors suggesting acinar origin were uniformly more medullary. Various degrees of differentiation were found, varying from well oriented glandular structure to extreme anaplasia, suggesting sarcoma.

The size of the primary sites showed marked variation. The actual dimensions are not included in this study. Difficulty in judging exact size of some of the larger tumors was encountered because of the merging of metastatic nodes with primary tumor mass and regional extension. In general, the acinar tumors were larger and more medullary. In 1 case, the primary tumor measured 1.5 by 1 centimeter on cross section. By involving the adjacent duct over a narrow segment, this tumor led to the classical picture of painless progressive jaundice over several weeks' duration.



Fig 3 Direct extension of cancer of head of pancreas to common bile duct with annular stenosis and obstruction

The patient survived a cholecystoduodenostomy by only a few days, but at autopsy the lesion was distinctly operable. It is regrettable that the primary tumor was not found at the exploratory exposure and a resection of the head of the pancreas attempted. It is this type of lesion which offers the best prognosis for permanent cure by surgery, inasmuch as the symptoms appear before metastasis renders the lesion inoperable. In general, the tumors of the head of the pancreas were smaller. All neoplasms of the body or tail were obviously inoperable with metastasis present at the time of autopsy.

#### ANALYSIS OF MECHANISM OF OBSTRUCTION

It is commonly taken for granted that jaundice in cancer of the head of the pancreas is due to "extraductal" compression of the common bile



Fig 4. Photomicrograph of section of cancer of the head of the pancreas with bulky papillary extension to duct with filling of lumen.

duct, for widespread liver metastasis is exceptional (Courvoisier Adler Duff Lockwood). Jaundice in cases of cancer of the body the tail or both body and tail is likewise usually explained by compression of the biliary tract by metastatic lymph nodes in the region of the porta hepatis. Whereas it might be understandable that a growing mass in a fixed organ like the pancreas might cause compression of the ducts, enlarging lymph nodes at the porta hepatis do have room for expansion and should not cause obstruction unless they are fixed to the duct wall to the surrounding structures or to both. Such fixation of bile duct structures by tumor was invariably found in our cases. Cancer was present not only in the lymph nodes along the biliary tract, but was also present in the wall of the duct itself. Likewise passive compression alone of the common duct within the head of the pancreas proper is not borne out by our experience. There was cancerous invasion of the biliary duct wall in all cases of cancer of the head with jaundice (Figs 2-3). In the 19 cases

with obstructive jaundice 18 showed on microscopic study histological invasion of the wall by tumor tissue. In the sole remaining specimen, the gross involvement of the duct wall was obvious. It is therefore believed that malignant involvement of some part of the biliary tract is a prerequisite for the production of the biliary obstruction responsible for the jaundice associated with cancer of the pancreas.

The observation of several large cancers of the pancreas some 10 years ago, and also of a large pancreatic cyst, which displaced and distorted the common duct markedly, with obvious flattening and compression of the lumen and, nevertheless, failed to give any evidence of jaundice or other evidence of obstruction, seemed to give added weight and significance to our observations. Even at that time, every case that has shown definite obstruction with persistent jaundice has invariably shown to some degree invasion of the duct wall by tumor tissue.

From the primary tumors of the head of the pancreas, the common bile duct was involved in 12 of the 13 cases with obstruction. In 9, the intrapancreatic portion was invaded by direct extension from the primary tumor. In 3, the extra-pancreatic portion, just below the junction of the cystic and hepatic ducts, was involved by extension from metastatic carcinomatous lymph nodes. In only 1 case was the extrahepatic biliary tract found free. This was one of the 2 cases with massive liver metastasis, in which the intrahepatic ducts near the hilus were definitely invaded. Gall-bladder enlargement was present in 9 cases, one of which also showed calculi. The 3 cases without enlarged gall bladders showed evidence of fibrosis or chronic cholecystitis and cholelithiasis, and this was deemed adequate to explain the failure of dilatation.

In the cases of cancer of the body or tail or of both, the upper extra-pancreatic portion of the common bile duct was invaded in 3 cases, all of which showed gall bladder enlargement. In 2 cases the common hepatic duct was involved, and in 1 both the right and left hepatic ducts were involved. The latter case is particularly pertinent for the consideration of the mechanism we are stressing. In this last case the left hepatic duct, as more completely occluded than the right duct, and, corresponding to the degree of stenosing obstruction, the left lobe of the liver showed deeper blue staining than the right. As would be expected, there was no enlargement of the gall bladder when the obstruction was above the cystic duct.

The infiltrating cancer was in some cases limited to the outer layers of the duct wall, but in most

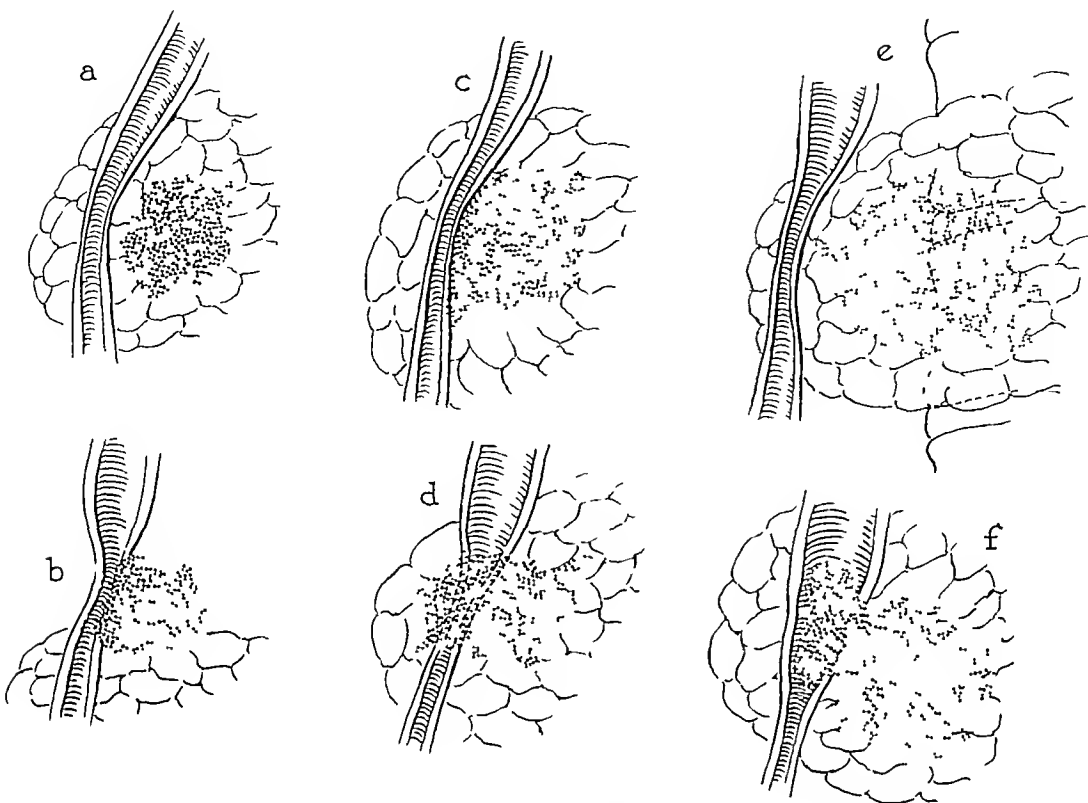


Fig 5 Diagrammatic representations of mechanisms of obstruction of duct by cancer *a*, Tumor mass in head of pancreas displacing but not obstructing lumen of duct *b*, Tumor mass just above pancreas, possibly lymph node, extending to wall with local annular stenosing scirrhous reaction causing obstruction of relentless progressive character Detailed diagram seen in Figure 6 *c*, Tumor in head of pancreas extending to wall of duct, fixing and displacing same, with some narrowing of lumen *d*, It is obvious that progressive growth of tumor as a whole leads to fur-

ther direct impingement upon lumen *d*, Tumor of head of pancreas with extension to duct wall and mechanism of annular stenosis and tumor extension both operative in producing obstruction *e*, Tumor of pancreas which is fixed to vertebral bodies which also displaces the duct, with linking and narrowing of lumen *f*, Tumor of head of pancreas without scirrhous reaction with medullary tumor extension into lumen often associated with intermittent jaundice brought on by repeated sloughing of interluminal tumor extension

cases the mucosa was also involved, with secondary ulceration. In one case there was polypoid extension of the tumor into the lumen (Fig 4). Secondary necrosis and sloughing of this growth allowed regression of the jaundice as is frequently seen in primary tumors of the ampulla, biliary tract proper, or stone in the duct. Invasion of the intrahepatic and extrahepatic biliary ducts as a factor in the production of jaundice in cancer of the pancreas has been mentioned by several authors, but its constant presence in these cases has not been stressed.

#### DISCUSSION OF MECHANISM

There are three separate factors in the production of the obstruction of the biliary tract in this

series (Fig 5). First, *invasion fixes* the wall of the duct and permits of physical compression with narrowing of the lumen in lieu of mere displacement by adjacent expanding tumor mass. Second, and this is the more common and more important mechanism in our experience, the invasion of the duct wall is accompanied by a scirrhous reaction with the production of an annular *stenosing* lesion with localized segmental narrowing and obstruction of the lumen (Fig 6). This occasions the classical syndrome of "pancreatico-bilaire" more often. A small resectable tumor or a localized area of extension from a metastatic lymph node to the duct can produce this classical picture. Finally, the invasion of the duct wall may be associated with extension to, and *filling* of, the

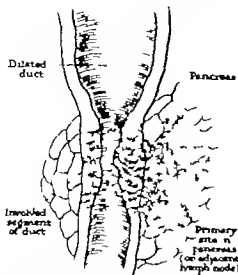


Fig. 6. Diagrammatic representation of the most common mechanism of obstruction from primary site in pancreas or adjacent lymph node. As could be expected this sclerous annular progressive constriction is seen in sclerous tumors of the pancreas, the most common form.

lumen with tumor tissue with obstruction of the flow of bile. This last lesion is often associated with a cellular medullary or papillary type of growth and by sloughing may give periods of spontaneous remission of jaundice.

An identical mechanism, i.e., metastases to lymph nodes and then extension to biliary tract, was found to account for the jaundice in cases of primary cancer of the stomach and colon which did not have extensive liver metastases. In several such instances, there were found metastases to the lymph nodes at the porta hepatis with secondary invasion of the bile ducts. The fact that massive liver metastases with very little remaining liver parenchyma is often unassociated with jaundice lends significance to the smaller nodules involving the intrabiliary ducts near the hilus for the production of the icterus. This suggests that in cases of massive liver metastasis also duct invasion may be a prerequisite for jaundice.

#### SUMMARY AND CONCLUSION

Thirty-nine cases of cancer of the pancreas have been reviewed. Nineteen cases showed the presence of jaundice—3 originating from the head, and 6 from the body or tail. There was carcinomatous invasion of some part of the biliary tract in all cases with jaundice. Obstruction by compression

alone was not encountered. Some degree of fixation of the duct seems necessary for effective obstruction by mechanical compression by adjacent tumor.

Obstruction leading to the syndrome of painless progressive jaundice is most often due to focal stenosing annular sclerous carcinomatous involvement of duct wall. Occasionally there is papillary extension into the lumen in such cases sloughing may produce intermittent or waxing and waning jaundice.

This mechanism of jaundice also applies to jaundice in cases of metastases from other foci, when in involvement of the extrahepatic ducts or the larger intrahepatic ducts deep in the liver or at the hilus may become the pertinent mechanism.

The theoretical basis for cure by a resection of the head of the pancreas in early cases of cancer of the pancreas despite an advanced syndrome of progressive jaundice is implied. The known evolution of the syndrome of painless progressive jaundice occasionally by stone in the duct, is a further indication for early laparotomy in all cases of persistent jaundice.

#### REFERENCES

1. ADAMS, F. D. *Arch. Int. M.* 92: 27-33-53.
2. ADAMS, F. H. *J. Am. M. Ass.* 9: 70, 57-59.
3. BARD, L. and MAC, L. *Rev. med.* 78, 6-237.
4. BARNES, NORA. *Arch. Int. M.* 92, 33-367-4.
5. CURTIS, H. M. *J. Am. M. Ass.* 92, 97-9-97.
6. COLEMAN, C. *Concise Anatomische Beschreibung der Pathologie und Chirurgie der Gallenwege*. Leipzig: F. C. W. Vogel, 1900.
7. CULL, G. *Am. J. Surg.* 1900, 47-87-95.
8. DUFF, G. L. *Am. J. Surg.* 1900, 110-110-110.
9. EINHORN, MAX. *Am. J. M. Sc.* 92, 7-70-70.
10. ELLIOTT, G. B. and WILSON, D. L. *South M. J.* 92, 30-87-87.
11. FORD, S. C. *Am. J. Digest. Dis.* 94, 8-65-65.
12. FREUDENBERG, J. and COLLIER, T. S. *Am. J. M. Sc.* 92, 97-3-4.
13. GLENN, F. *Washington Univ. M. Alumni Quart.* 92, 3-3-3.
14. GRUBER, E. A.  *Diseases of the Liver and Biliary Passages*. Surgical Diagnosis. Vol. 2, p. 47. Philadelphia: W. H. Saunders & Co. 1930.
15. GRUBER, F. W. *Arch. Int. M.* 92, 63-63-63.
16. HAN, C. C. *Am. J. Digest. Dis.* 92, 3-4-63.
17. HARR, F. K. and STORMSH, H. M. *J. Lab. Ch. M.* 92, 9-97-97.
18. LAMONT, F. H. and ST. KINNON, D. C. *Surg. Clin. N. America.* 92, 8-63-704.
19. LEVY, N. L. *Am. J. Cancer.* 92, 8-23-2-4.
20. LOCK, C. D. *J. Am. M. Ass.* 19: 77-77-77.
21. MCKINNON, D. C. *Minnesota M. J.* 92, 3-74-74.
22. MCKINNON, D. C. *Ill. M. J.* 92, 3-74-74.
23. MCKINNON, D. C. *Am. J. Surg.* 92, 40-64-4.
24. MCKINNON, D. C. *Am. J. Surg.* 92, 30-74-74.
25. WATKINS, A. U. *Am. Surg.* 94, 4-61-61.



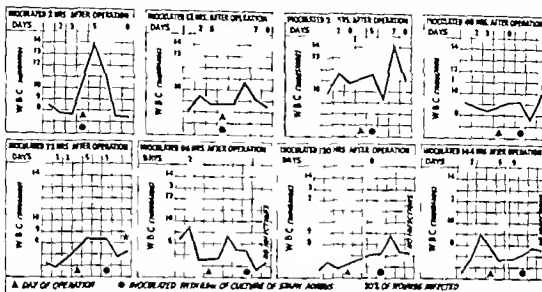


Fig. The leucocyte response following inoculation of an abdominal incision with 0.3 cubic centimeter of culture of *Staphylococcus aureus*. The graphs are prepared by

PERKINS, M. D. series of experiments. Each star indicates 30 per cent of infected wounds and they are placed on the day on which the infections occurred after inoculation.

#### EFFECT OF INOCULATION OF HEALING WOUNDS AFTER REMOVAL OF STITCHES

Fourteen guinea pigs were operated on as previously described. Stitches were removed from incisions made 2, 24, 48, 72, 96, 120 and 144 hours previously. In each instance 0.3 cubic centimeter of a 6 hour culture of *Staphylococcus aureus* was rubbed on the wound with a sterile cotton swab immediately after removal of the stitches. The experiments were then repeated on 14 more guinea pigs to check the virulence of the culture. Incisions were made 12 to 144 hours before all stitches removed and wounds inoculated the same day.

The results in both groups were the same. All wounds were infected which had been made 12 and 24 hours previously. Eighty per cent of 48 hour wounds were infected, 50 per cent of 72 hour wounds were infected, 20 per cent of 96 hour wounds were infected and none were infected at 120 and 144 hours.

#### ANATOMICAL EXTENT OF LOCAL IMMUNITY

A group of experiments was now done to determine whether wound immunity is due to local or systemic factors or both and to learn

how wide an area is protected by the regional immunity.

A left paramedian abdominal incision was made and sutured as described in previous experiments but no organisms were purposely introduced. At the conclusion of the operation a right paramedian incision was made and 0.3 cubic centimeter of a 6 hour culture of *Staphylococcus aureus* was introduced in the second incision. The second incision was made in other guinea pigs at the end of 12, 24, 48, 72, 96, 120 and 144 hours after the first incision. In each instance the culture was introduced at the time of the second operation into the second wound. The wounds were closed with interrupted silk sutures. Each experiment was repeated 4 times varying the site of the second incision in the abdominal wall.

The entire experiment was then repeated 12 guinea pigs were used and 2 of them were operated upon on each of 6 successive days. On the 6th day the second incisions were made in various sites of the abdomen, 0.3 cubic centimeter of the culture being introduced in each second incision on the same day, thus eliminating variation in the virulence of the culture.

In a third group the first incision was reopened at the time that the second incision was made and the culture was introduced in both wounds

Infections occurred in all second incisions made immediately after the first and inoculated, also in all incisions made 12, 24, and 48 hours later. Eighty per cent of the second incisions were infected when made and inoculated 72 hours after operation and 50 per cent when made and inoculated 96, 120, and 144 hours later

In the third group the first incision behaved very much as in previous experiments except that immunity was not established until 144 hours after operation. All second incisions were infected when made and inoculated 12, 24, and 48 hours after the first. Fifty per cent of second incisions made after 96 hours and inoculated became infected

#### ANALYSIS OF RESULTS

Du Mortier found that 56 per cent of his guinea pigs became infected when *Staphylococcus aureus* was implanted 2 days after operation, and that complete immunity did not occur until the 5th day. Since our pigs were not restrained it is reasonable to suppose that respiration, circulation, and hydration were normal. These factors together with the omission of bandages may have hastened local immunity in our animals. This is further substantiated by the fact that local immunity did not occur until the 6th day when 2 incisions were made at different times. The second incision may have delayed the process of immunity

It is interesting to note that 100 per cent of the pigs were infected when *Staphylococcus aureus* was rubbed on the wound at the end of 2, 12, and 24 hours, whereas previous studies (3) revealed that only 67.5 per cent were infected when the culture was introduced into the wound at time of operation. This is in accord with clinical experience, for Koch and others have shown that most wounds although primarily contaminated are more often infected later when treated without strict asepsis. We cannot say what rôle the vigorous rubbing played but it undoubtedly added trauma and destruction of some cells although

the scabs were not rubbed off by the process. On the 3d day only 20 per cent became infected, and none were infected on the 4th, 5th, or 6th days

When stitches are removed immunity does not occur as early. Wounds were not immune until the 5th day whereas the former groups were immune on the 4th day. But in the process of removing stitches more trauma is inflicted. Scabs were removed and bleeding occasionally occurred

Previous incisions made in the abdominal wall do not protect fresh incisions against staphylococcal infections. Local immunity is apparently limited to the zone of granulation tissue and does not extend beyond this zone. In this way it corresponds to the pyogenic membrane or leucocytic barrier referred to in localized infections. However, on the 4th day following a previous incision and thereafter as long as the experiments were continued only 50 per cent of second incisions became infected. This would indicate some degree of regional and general immunity. Temperatures and leucocyte counts tend to bear out the latter as shown by our previous studies

When the first wound was reopened and inoculated, immunity did not occur until 6 days in contrast to 5 days when stitches were removed and 4 days when the culture was rubbed on the undisturbed wound. At 6 days the second wounds were infected in 50 per cent of the animals although the old incisions were immune

This observation indicates that any trauma to granulation tissue delays the onset of local immunity, also systemic and local disturbances such as infected second wounds may cause the delay. Previous studies showed an incidence of infection in 67.5 per cent when cultures are introduced in a freshly made incision. We have shown that when a second wound is made immediately after the first or when made 12, 24, or 48 hours later, 100 per cent of these second wounds become infected. We may therefore deduce that there is a decrease in regional resistance over the entire abdominal wall for a period of 48 hours. On the 4th day there is an increase in resistance and only 50 per cent of second wounds are infected. Similar results were obtained by



scrubbing the abdomen (1) without the previous incisions, a fact indicating that the increased resistance may be due to the reaction caused by the trauma of scrubbing or of the incision. A great increase in blood supply was noted at the time of all second incisions. This evidently was only one of the factors involved in increasing local resistance.

Lastly, the behavior of the first wound varied slightly in the presence of a second one. That is, immunity was delayed but was none the less complete. This was probably due to the increased trauma of reopening the wound. But the complete immunity which occurred on the 6th day further corroborated previous observations that the area of immunity is limited to the zone of granulation tissue.

#### OBSERVATIONS

Our experiments show that a wound is about 33 per cent more susceptible to infection during the first 24 hours than it is at the time it is inflicted. We have always believed that if a wound can be carefully scrubbed with soap and water during the first 6 hours it could probably be rendered sufficiently sterile to permit healing by first intention. This result occurs if the scrubbing can be done under strict aseptic technique. In combat zones it is probably better not to attempt sterilization but merely to ligate major bleeding vessels and apply a sterile pressure bandage to burned and traumatized areas. This procedure limits the loss of blood and plasma into the injured area thereby reducing the incidence of shock and infection (2). Above all however it prevents the possible introduction of bacteria into a more susceptible wound. If a clean-up process together with removal of foreign bodies or final reduction of a compound fracture is to be done, it is preferable after the 6th day. Sulfonamides given by mouth or parenterally at the time of injury will reach

the wounds and blisters during their exudative phase. Since the wounds treated by this method are not sutured, anaerobic infections are less apt to occur. In addition tetanus toxoid and polyvalent gas gangrene antitoxin should be used. Should infection occur bandages must be removed and the areas treated as open infected wounds.

Surgeons have long ago learned not to enter the abdomen through a gunshot wound. An incision is made depending on the site of entrance and exit of the bullet. The bullet wound is excised or unmolested—the rationale for the latter procedure is clearly demonstrated by our experiments.

#### CONCLUSIONS

1. Healing wounds are more susceptible to contamination by *Staphylococcus aureus* during the first 24 hours than are fresh wounds.
2. Immunity in a healing incision which is not traumatized occurs 4 days after surgery.
3. When sutures are removed from a healing wound immunity does not occur until the 5th day after operation.
4. If the wound is reopened this immunity does not occur until the 6th day, due probably to the trauma incurred in reopening.
5. The anatomical extent of wound immunity seems to be limited to the area surrounded by granulation tissue.
6. The entire abdominal wall around a previous incision is less susceptible to staphylococcus implantation after the 4th post-operative day.

#### REFERENCES

1. BEN, J. K. *Ann Surg* 94: 700-77.
2. Idem. *Synopsis of the Principles of Surgery*. Pp. 739. St. Louis: C. V. Mosby Co. 1930.
3. BENNETT, J. K., HARTMAN, A. D. and K. T. W. *Ann Surg* 94: 733-341.
4. DE MONTMAY, J. J. *Surg Gyn Obst* 93: 50-74.
5. KOCK, S. L. *Surg Gyn Obst* 94: 70-79.

# THE SURGICAL MANAGEMENT OF PROLAPSE OF THE UTERUS AND VAGINA

## A Report of 730 Personal Operations

LOUIS E. PHANEUF, M.D., Sc.D. (Hon.), F.A.C.S., Boston, Massachusetts

**U**TEROVAGINAL prolapse is one of the commonest lesions encountered in the practice of gynecology. While the disorder in itself is not responsible for the loss of human life, it is the cause of untold discomfort and suffering. In approaching this problem from the surgical standpoint, it must be borne in mind that since *a priori* uterovaginal displacement does not cause death, the method employed for the correction, in order to justify itself, must have a very low operative mortality. Because of the multiplicity of complicating lesions associated with uterovaginal prolapse, it is obvious that no one operative procedure can be applied in all cases and that the best operative results will be obtained by individualizing.

My interest in this lesion covers a period of 27 years, during which time I have employed practically all the standard procedures and have tried to estimate their value impartially. During these years I have performed 730 operations for prolapse of the uterus and vagina, the data concerning which are given in tables.

Five factors are fundamental in determining the method of treatment: first, the age of the patient; second, the possibility of future pregnancies; third, the extent of the prolapse; fourth, the size of the uterus; and fifth, whether or not coexisting disease is present. For practical purposes uterovaginal prolapse may be classified in three degrees: first degree prolapse, when the cervix appears at the vulva; second degree prolapse, when the cervix is extruded; and third degree prolapse, or procidentia, when the entire uterus is found outside of the vulva.

### TYPES OF OPERATION

*Vaginal plastics and abdominal suspension or fixation of the uterus.* In this group there were 117 cases.

It is conceded by most gynecologists that with few exceptions young women in the childbearing

From the Department of Gynecology, Tufts College Medical School and the Gynecological and Obstetrical Service, Carney Hospital.

Read before the Michigan Society of Obstetricians and Gynecologists February 2, 1943.

age should be treated conservatively, whenever possible, until their families are completed, at which time they may be subjected to corrective operations for their displacements, vaginal or uterine. During this stage of observation the cervix is the one organ that usually needs attention since, accompanying most prolapses, a laceration of the cervix with ectropion and erosion is a prevalent finding. If it is found advisable to postpone operation, the cervix should meanwhile be healed by cauterization or conization after each pregnancy. This accomplishes two purposes: it relieves the patient of an annoying discharge, and it may serve as a prophylactic measure against the development of cancer of the cervix. To put it another way, all irritative lesions of the cervix uteri should be healed between pregnancies in order to reduce the incidence of cancer. The discomfort occasioned by the lesser degrees of prolapse may be relieved by the wearing of a well fitted pessary. Those young women who have extensive prolapse should be operated upon. The operative procedures in the younger group of patients are fairly well standardized and consist of repair of the cervix by trachelorrhaphy, as well as repair of the anterior and posterior vaginal walls and of the perineum. By means of a laparotomy, the uterosacral ligaments are shortened in order to bring the cervix to its normal position and at a right angle with the vagina, and the uterus is suspended by the round ligaments. This form of reconstruction restores the pelvic organs as nearly as possible to their original state, and, in my experience, has not interfered with subsequent pregnancies and labors. In order to obviate relaxation and laceration of the repaired perineum, an episiotomy is generally performed at a subsequent delivery. High amputation of the cervix and fixation of the uterus to the anterior abdominal wall are avoided during the childbearing age, because they predispose to sterility, abortion, and miscarriage and because of the severe dystocia that these procedures will obviously cause during later labors. In women past the menopause amputation of the cervix and fixation of the uterus are employed if, for one



TABLE III—ADDITIONAL DIAGNOSIS<sup>1 2</sup>

Myomas of the uterus	41
Epidermoid carcinoma of cervix	1
Adenocarcinoma of corpus	3
Senile atrophic uterus	57
Cervical polyp	17
Previous abdominal fixation of uterus	5
Fibrosis of the uterus, menometrorrhagia	7
Myoma of anterior vaginal wall	1
Cyst of perineum	2
Third degree laceration of perineum	15
Rectovaginal fistula	2
Ulcer of vagina	8
Laceration of right labium minus	12
Laceration of left labium minus	1
Edema of vaginal walls	1
Vesical calculus	1
Urethrocele	3
Urethral caruncle	1
Old suburethral abscess	5
Urethral prolapse	1
Hypertrophied suburethral fold	11
Ovarian myoma	1
Ovarian cyst, left	3
Ovarian cyst, right	1
Cystic ovaries	4
Calcified tumor of right ovary	1
Persalpingo oophoritis	1
Rectal prolapse	4
Hemorrhoids	38
Cholelithiasis	4
Lipoma right thigh	1
Umbilical hernia	1
Inguinal hernia, right	1
Inguinal hernia, left	1
Diabetes	13
Previous vaginal operation for prolapse	22
Previous vaginal plastics and suspension or fixation	45
Old pelvic hematocele	1
Ankylosis both knees	1
Chronic appendicitis	13
Relaxed vesical sphincter	4
Endometriosis	4
Megalocolon	1
Ruptured corpus luteum with hemorrhage	1
Incarcerated femoral hernia	1
Fundal polyps	3
Incisional hernia	3
Perineovaginal fistula	1
Varicose veins (severe)	1
Lipoma of left buttock	1

<sup>1</sup>Cervical pathology in the form of erosion, laceration ectropion ulceration and hypertrophy was found in all cases except those of nulliparous prolapse.

<sup>2</sup>In the above table urethroceles are said to have occurred three times. A word of explanation may be necessary. In all cases of cystocele associated with prolapse there is found a certain amount of bulging of the posterior urethral wall and some relaxation of the vesical sphincter. In all operations for cystocele this has been corrected by plicating the musculofascial tissues on the sides of the bladder in one or two layers as indicated thus overcoming the bulging in the posterior urethral wall. The three urethroceles mentioned in the table are those in which the posterior wall formed a large hernial sac.

time force down such an atrophied interposed uterus so that the cervix appears at the vaginal introitus, although there may be no recurrence of the cystocele. It has been shown that severe vesical disturbances may follow the interposition operation. Obviously vesical pain will occur

TABLE IV—ADDITIONAL OPERATIONS<sup>1 2</sup>

Myomectomy or hysterectomy (vaginal or abdominal)	41
Vaginal hysterectomy for epidermoid carcinoma of cervix	1
Vaginal hysterectomy for adenocarcinoma of corpus	3
Cervical polypectomy	17
Myomectomy for myoma of anterior vaginal wall	1
Resection of cyst of perineum	2
Perineorrhaphy for complete laceration of perineum	15
Repair of rectovaginal fistula	2
Repair of right labium minus	2
Repair of left labium minus	1
Extraction of vesical calculus	1
Repair of urethrocele	3
Fulguration of urethral caruncle	5
Excision of abscess, wall of urethra	1
Fulguration for urethral prolapse	4
Resection of hypertrophied suburethral fold	11
Ablation of ovarian tumors	6
Puncture of cystic follicles	4
Operation for rectal prolapse	4
Hemorrhoidectomy	38
Excision of lipoma of right thigh	1
Umbilical herniotomy	1
Inguinal herniotomy	2
Appendectomy	13
Plication of vesical sphincter	4
Femoral herniotomy	1
Incisional herniotomy	3
Repair of perineovaginal fistula	1
Excision of lipoma of left buttock	1

<sup>1</sup>Cervical repair in the form of amputation, trachelorrhaphy and cauterization was performed in all patients in whom the uterus was retained.

<sup>2</sup>Under "Plication of Vesical Sphincter" 4 cases are mentioned. In all cases of cystocele, when the musculofascial tissues are plicated the vesical sphincter is also repaired. The 4 cases mentioned in the table were extreme cases in which additional operative procedures were necessary.

whenever the uterus is pulled between the bladder pillars and the uterine fundus is attached to the anterior vaginal wall, since the fundus of the uterus under such conditions will exert a constant pull on the bladder and will cause its sacculation. Bladder symptoms, however, are infrequent if the bladder pillars are severed and the bladder is completely separated from its attachments to the vagina and uterus. It will then lie smoothly and not in folds, on the superior and posterior surfaces of the uterus, and, since there is no traction on this viscus, pain will not be experienced. In the interposition operation, as well as in all methods in which the uterus is retained in the management of uterovaginal prolapse, recurrences can be more easily corrected by having the uterus to work with than when it has been removed.

*Vaginal hysterectomy with interposition of the broad ligaments.* There were 125 cases in our series.

Vaginal hysterectomy for prolapse is valuable when the uterus shows marked senile atrophy and when because of certain pathological conditions its removal is thought to be in the patient's interest. In performing this operation I have found

TABLE V.—OPERATION FOR POSTERIOR VAGINAL ENTEROCHELE

Vaginal resection of cul-de-sac of Douglas, Ward operation.	4
Abdominal obliteration of cul-de-sac of Douglas, Manchewitz type of operation	
Total colectomy	
Subtotal colectomy—LeFort operation	
Total	54

it advantageous to ligate the broad ligaments in three sections, the lowest section including the uterosacral ligament on each side. The broad ligaments are approximated in the median line by tying together the three sutures of each side. The cul-de-sac of Douglas is closed by approximating the uterosacral ligaments in their entire length by means of interrupted sutures. The united broad ligaments are then attached to the anterior vaginal wall, after resection of the vaginal flap of each side, by means of similar sutures. This method of approximating the broad ligaments is responsible for tying the vessels more securely and causing less tension than occurs with a continuous mattress suture as recommended in the original Mayo operation. The closure of the cul-de-sac of Douglas is one of the most important steps of the operation, since this procedure may be the means of preventing the formation of a future posterior vaginal enterocele.

**Vaginal hysterectomy—clamp method** In this group there were 36 cases.

Vaginal hysterectomy by the clamp method, as elaborated by Joseph Price and popularized by James W. Kennedy, has two distinct advantages: the rapidity with which it may be performed and its excellent results. When performed for prolapse it is profitably carried out in 10 steps. The first step comprises the ablation of the uterus and the repair of the anterior vaginal wall by means of nonabsorbable sutures. The second step, which consists of repair of the pelvic floor, is best carried out 2½ to 3 weeks after operation when the vaginal vault and the anterior vaginal wall have healed. When this method is employed, I usually repair the perineum under local infiltration anesthesia and have also performed the entire operation under the same anesthesia. It is well tolerated by feeble women and by poor surgical risks, since its performance consumes only a few minutes. Its only disadvantage rests in the fact that it requires longer hospitalization than does vaginal hysterectomy by means of sutures. This, however, is frequently advantageous to the patient since the extra days of rest in the hospital result in noticeable improvement in her general physical condition.

TABLE VI.—ANESTHESIA

	General	Spinal	Local	Pain nachs	Total
Vaginal plastic and abdominal incision or fixation of uterus	37				
Uteropexy operation	38	45			83
Vaginal hysterectomy with incision of broad ligaments	67	38			
Vaginal hysterectomy clamp method		29			29
High vaginal fixation of uterus	26	29			55
Manchester operation—LeFort operation		35			
Subtotal colectomy—LeFort operation		6	8		14
Total colectomy					
Operation for posterior vaginal enterocele	29	11			40

**High vaginal fixation of the uterus** High vaginal fixation of the uterus in the treatment of uterovaginal prolapse has never been a popular method in the United States, and is but rarely mentioned in the literature. It produces excellent results in first degree and second degree prolapse and I have found it most helpful in a certain group of cases, such as recurrences after previous vaginal plastics and abdominal fixation of the uterus, these recurrences being difficult to correct because of the tremendous elongation of the uterus in most cases. There are 57 cases in our series. By opening the anterior vaginal wall, separating the bladder from the vagina and uterus and by exerting strong traction on the cervix, it is possible to pick a point on the anterior surface of the uterus corresponding to the highest point in the vaginal location, just below the urinary meatus. The anterior surface of the uterus at this level is picked up by suture, the two ends of which are threaded through the vaginal wall on each side and tied, thus raising the bladder high in the pelvis. After a high amputation of the redundant cervix, the remainder of the anterior uterine wall is sutured to the vagina by interrupted sutures, and the perineum is repaired. Every recurrence in the class of cases here described, which has come under my observation and treated by this method thus far has given a satisfactory and durable result.

**Manchester or Fothergill operation** The Manchester or Fothergill operation is based on uniting the bases of the broad ligaments (cardinal ligaments) in front of the cervix with amputation of this organ when necessary, performing a wide

In the group in which high vaginal fixation of uterus was done, the following was noted

Recurrence 2 years and 8 months after operation—large posterior vaginal enterocele—corrected by Ward's vaginal operation for enterocele

Recurrence, 8 years after operation—in the form of first degree prolapse, due to lifting and straining while moving to another house—was not corrected

Recurrence 3 years and 4 months after operation—very small atrophied uterus, cervix extruded on straining—corrected by vaginal hysterectomy with interposition of broad ligaments and Ward vaginal operation for enterocele, perineorrhaphy

Recurrence 4 months after operation—cervix extruded on straining—not corrected Amputation of cervix was advised, but was refused

Of the group in which the Manchester operation (Fothergill operation) was used the recurrences were as follows

Recurrent cystocele noted a few months following operation—patient 68 years of age, and refused a second operation

Recurrence 1 year and 4 months after operation—medium posterior vaginal enterocele—corrected by Ward vaginal operation for enterocele

Recurrence 1 year and 7 months after operation—small cystocele—not corrected

In the subtotal colectomy (LeFort operation) group there was 1 recurrence

Recurrence 3 months after operation—cervix appeared at vulva—there were thin, atrophic tissues with poor blood supply and imperfect healing

In the total colectomy group there were no recurrences observed thus far

In the group having operation for posterior vaginal enterocele, the following was noted

Recurrence a few months after operation—slight bulging of cul de sac of Douglas on straining after the Moschowitz operation for enormous hernia No correction was necessary

Recurrence a few months after operation—slight bulging of the cul-de sac of Douglas after the Moschowitz operation for a large enterocele. No correction was necessary

In 1 case separation of the skin of the perineum due to poor blood supply of tissues was corrected by the edges being freshened and approximated with prepared silk. Good healing

#### CONCLUSIONS

Uterovaginal prolapse in young women during the childbearing age may be satisfactorily treated by repairing the cervix, the anterior and posterior vaginal walls and the perineum, by shortening the uterosacral ligaments, and by performing a round ligament suspension of the uterus

After the menopause one of the vaginal methods is given the preference because of increased operability, on account of lessened morbidity and mortality. An abdominal incision is made only in

a very limited number of cases to correct a recurrence and to obliterate a very large posterior vaginal hernia

The interposition operation (Watkins-Schauta-Wertheim) followed by amputation of the cervix gives excellent results in properly selected cases, and this operation has been used in the largest number of cases in this series

Vaginal hysterectomy with interposition of the united broad ligaments is reserved for women with atrophied uteri and in whom cancer is present or suspected

Vaginal hysterectomy, clamp method, is ideal in old women when hysterectomy is indicated and when the time element is a factor

High vaginal fixation of the uterus with amputation of the cervix is useful in the first and second degrees of prolapse, with a large cystocele, and when recurrence has occurred subsequent to an abdominal fixation of the uterus

The Manchester or Fothergill operation in recent years has supplanted the interposition operation and vaginal hysterectomy in a number of cases. Its technique is simple and its results uniformly satisfactory. It has the advantage of being a surface operation since the peritoneal cavity is not entered

In worn out and feeble old women, in whom an extensive vaginal operation is contraindicated, subtotal colectomy (LeFort operation) or total colectomy, especially when performed under local anesthesia, may render great service

One or the other method of colectomy may be used to advantage in inversion of the vagina following supracervical or total hysterectomy

A posterior vaginal enterocele (hernia of the cul-de-sac of Douglas) which not infrequently accompanies uterovaginal prolapse should receive adequate surgical treatment

An adequate repair of the pelvic floor is essential in all cases, with the rare exception of women with nulliparous prolapse in whom the perineum is intact and gives good support

The vaginal methods, because of the minimum amount of postoperative shock and the comfortable convalescence which follows, are ideal operations in older women

Local and spinal anesthesia may be used advantageously in a number of patients

#### REFERENCES

- 1 ALEKSANDROFF Russk Vrach, S Peterb, 1903, Vol 11
- 2 MARION Rev gyn chir abdom, Paris, 1909, 13 465
- 3 MOSCHOWITZ, ALEXIS V Surg Gyn Obst., 1912, 15 7-21
- 4 SHAW, FLETCHER. Am J Obst. 1933, 26 667-686
- 5 WARD, GEORGE GRAY J Am M Ass, 1922, 69 709-713

nonabsorbable material, care being taken not to include the ureters in these sutures. In 1913 Moschowitz described a similar but more extensive operation for prolapse of the rectum, this procedure being equally applicable to hernia of the cul-de-sac of Douglas. Finally in 1922 George Gray Ward proposed a vaginal operation for the radical cure of this disorder. His procedure carried out entirely through the vagina, consists of mobilizing the cul-de-sac of Douglas on all sides, opening the hernial sac, reducing its contents, ligating its base and resecting the sac. The uterosacral ligaments are then approximated to each other in their entire length as a barrier against recurrence and the pelvic floor is repaired. I have employed the Ward operation in most cases, and have reserved that of Marion and Moschowitz for very large hernias and those complicated by adhesions.

For the sake of clarity data regarding the 730 operations for uterovaginal prolapse which I have performed are presented in tables.

#### RESULTS

All 730 patients in this series were examined as they left the hospital at the end of 3 weeks, and the results were noted. All except those living at far distant points were re-examined at the end of 3 months, and many of them were again examined a year after operation. While it was fairly simple to check the primary results, it was extremely difficult to check the end-results. These operations were performed during a period of 27 years on women coming from the New England states, from states farther distant, and from some of the Canadian provinces. The long distances they had to cover prevented them from returning for subsequent examination. The questionnaire to the family physician or the patient proved to be of little value since in some who claimed good results in the reply letter I found what I should class as fair results on subsequent check-up examination, and again, those who claimed not to have been benefited materially showed excellent anatomical results when seen later. Furthermore, women operated on at a certain time in life may show a good result and 10 or more years later because of the atrophy of the tissues that has taken place during this time there may appear descent of the anterior or posterior vaginal wall or of the uterus. Recently two such recurrences were impressive. The first patient was considered to have had a good result for a period of 13 years and 3 months following an interposition operation. Her husband then became severely ill and in caring for him for a period of 8 months it was necessary

for her to lift him. She reported after his death at which time it was found that a small atrophied uterus was completely extruded. This recurrence was corrected by a vaginal hysterectomy with interposition of the broad ligaments, and the result, up to the present time, has been entirely satisfactory. The second patient remained well for 12 years and 4 months after an interposition operation and then, because of marked atrophy of the uterus and the fact that her occupation necessitated the lifting of heavy weights a recurrence became apparent. This also has been satisfactorily corrected by vaginal hysterectomy.

The rate of recurrence in all operations for prolapse will no doubt increase with the length of time that the patients are examined. Thus far the following recurrences have been noted in those who have reported for check-up examinations.

Of the group in which vaginal plastic and abdominal suspension or fixation of the uterus was the type of treatment used recurrent cystocele was found 1 year and 3 months after operation in a patient with nulliparous prolapse.

In the interposition group the following results were noted

Recurrence 6 years after operation—extrusion of cervix—corrected by amputation of cervix, perineorrhaphy and abdominal fixation of uterus

Recurrence years and 3 months after operation—trophy—corrected by right oophorectomy myomectomy and abdominal fixation of uterus

Recurrence years and 4 months after operation—atrophy—corrected by vaginal hysterectomy and interposition of broad ligaments

Recurrence 3 years and 8 months after operation—trophy—patient 73 years of age and refused correction

Recurrence years and 6 months after operation—trophy—patient 70 years of age, and refused correction

Recurrence 6 months after operation—corrected by perineorrhaphy and abdominal fixation of the uterus

Recurrence 3 years and 3 months after operation—atrophy—corrected by vaginal hysterectomy with interposition of the broad ligaments

Recurrence month after operation—cervix of an trapped uterus extruded—corrected by abdominal fixation of the uterus

Recurrence 8 months after operation. First operation consisted of vaginal plastic and suspension elsewhere second operation, interposition operation, amputation of cervix and perineorrhaphy

Recurrence in the form of posterior vaginal enterocele corrected by Ward Apical operation for enterocele

Recurrence 6 months after operation, corrected by vaginal hysterectomy with interposition of broad ligaments

Recurrence year and months after operation atrophy—no correction

Recurrence year and month after operation Patient as operated upon in the country. The bladder was allowed to distend up to 32 ounces for months after operation. Recurrence was in the form of large cystocele and was corrected by vaginal hysterectomy with interposition of broad ligaments.

TABLE I—REPORTED CASES OF ASEPTIC MENINGITIS

Authors	Cases after lumbar puncture only	Cases after spinal anesthesia	Agent	Time of onset after operation	Clinical course	Outcome
Spiller and Payne	1					
Reynolds and Wilson	3					
Zahradicky		1	Procaine and adrenalin	Soon	Headache fever neck pain	Recovery 14th day
Dijon		1	Allocaïn		48 polymorphonuclear leucocytes	Death 20th day, No autopsy
Arnheim and Mage		1	Neocaine		No details given	
Hyslop		1	Neocaine	60 hrs	Increased spinal fluid pressure 480 cells with 90% lymphocytes Stupor and stiff neck	Recovery
Campbell		1	Nupercaine	8 hrs	Headache, vomiting fever 3000 cells with 80% polys 18% small monos and 2% large monos Had repeated cisternal punctures with antimeningococcal serum injected	Death 30th day Autopsy, monocytic meningitis—etiology undetermined
		1	Novocain	17 hrs	Headache fever 5400 cells with 90% polys to 3920 cells with 91% polys 4% small monos 3% large monos, and 2% transitional trace globulin and + sugar Recovered and discharged on 7th p.o. day Sudden onset of coma and death on 21st day	Death 21st day Autopsy acute purulent meningitis Etiology undetermined
Brock Bell and Davison		1	Procaine and strychnine	Soon	Spinal fluid contained lymphocytes mononucleosis beginning with 560 cells Symptoms gradually increased in severity and decreased by lysis	Recovery 22nd day
		1	Nupercaine	3 hrs	Coma. Polynucleosis of 3200 cells and disappearance of spinal fluid sugar	Recovery 5th day

preceding a partial hysterectomy performed elsewhere in 1933. On admission she presented a right lower abdominal mass, but otherwise was in good general condition. On November 12, 1941, an exploratory laparotomy and right oophorectomy were performed under spinal anesthesia. Morphine sulfate 0.010 gram (hypodermically) was administered 1 hour before the patient came to surgery. Ephedrine sulfate 0.049 gram (hypodermically) was given just before the lumbar puncture which was made in a rapid and uneventful manner at the third lumbar interspace. One hundred and forty milligrams of novocain crystals (from a 150 mgm. ampul) dissolved in 4 cubic centimeters of clear spinal fluid was injected. Ten minutes later anesthesia to pinprick was present to the 6th dorsal bilaterally. The operation consumed 1 hour and 5 minutes, and the anesthesia was very uneventful throughout.

Fourteen hours after surgery the patient developed a severe, throbbing headache which was generalized, nausea, bilateral tinnitus which was more intense in the left ear, and photophobia. Eight hours later the temperature was 101 degrees. At this time the only neurological finding was a cervical rigidity. Lumbar puncture revealed the spinal fluid to be of ground glass appearance with a cell count of 9,600 per cubic millimeter consisting of 99 per cent lymphocytes and 1 per cent polymorphonuclear leucocytes. Other findings, including chemical and microscopic examination of the spinal fluid obtained by repeated daily spinal punctures, appear in Table II. There was a gradual decrease in the symptoms and on the 5th postoperative day the cervical rigidity had disappeared. The course thereafter was uneventful, and on the 14th postoperative day the patient was discharged in good condition.

We have made careful postoperative observations in a series of approximately 4,000 cases of

TABLE II

Case and dates	Total Protein mgm %	Chlorides M/L	Sugar mgm %	Total cell count	% Lymphocytes	% Polymorphonuclear	Appearance	Initial pressure mm
Case 1—Operation on 11-7-41								
11-8-41	180	118.3		4000	99	1	Ground glass	170
11-9-41	58.8	118.3		552	90	10	Rapidly clearing	70
11-10-41	53.7	119.5	42	69	96	4	Clear	130
11-11-41	28.1	123.1		5	100	0	Clear	100
Case 2—Operation on 11-12-41								
11-13-41	221	119.5	46	9600	99	1	Ground glass	155
11-14-41	20	125.8	60	2200	95	5	Clear	150
11-15-41	231	126		103	94	6	Clear	

Pandy negative in both cases  
Culture showed in both cases no growth on any media including brain



# SO CALLED ASEPTIC OR CHEMICAL MENINGITIS

## Report of Two Cases

H LIVINGSTONE, M.D. V WELLMAN, M.D. D. CLARK, M.D. and V LAMIBROS, M.D.  
Chicago, Illinois

THE incidence of so called aseptic meningitis following lumbar puncture or spinal anesthesia is comparatively rare; however we believe that the condition is overlooked in some patients who particularly during the first four postoperative days, do not receive very close medical supervision by a person cognizant of this complication. Diagnosis of this condition should be made promptly and treatment instituted immediately in order to obtain quick relief from distressing symptoms. Orkin in a summary of 45,066 cases of spinal anesthesia reported by 20 authors, gives an incidence of 0.26 per cent of aseptic meningitis.

It is known that this complication can follow simple lumbar puncture. Spiller and Paine reported aseptic meningitis following lumbar puncture in an epileptic. Reynolds and Wilson reported three such complications following lumbar punctures on patients on whom previous diagnoses of cerebral syphilis, chronic encephalitis, and frontal tumor respectively had been made. The symptoms and findings were fever, stiff neck, positive Kernig sign, stupor and delirium. A pronounced increase in the cells in the spinal fluid was found without organisms being demonstrable by smear or culture and without reduction in the amount of sugar in the spinal fluid.

Zahradnick, Dijon, Arnheim and Mage and Hyndop have each reported one case of aseptic meningitis following spinal anesthesia, and Campbell, as well as Brock, Bell, and Davison, have reported cases. As can be seen in Table I, alcohol, novocaine, supercaine, novocain, and procaine with strychnine or adrenalin were the chemical agents employed.

Seven of these 8 cases appearing in Table I were reported in detail. The time of onset of symptoms varied from almost immediately after surgery to 60 hours after operation. Some or all of the following symptoms were observed in these 7 patients: headache, fever, pain or rigidity of the neck, meningismus or coma, malaise and anorexia, vomiting, haziness of the optic discs, increased

pulse rate, overactive knee jerk, positive Babinski signs, unilateral or bilateral Kernig and absent knee jerks and lower abdominal reflexes.

Lumbar puncture revealed turbid spinal fluid which upon microscopic examination presented a lymphocytosis, pleocytosis of polymorphonuclear leucocytes, or a monocytosis, with no organisms being demonstrable. Four patients recovered by the 5th to the 2nd postoperative days, while 3 succumbed on the 10th, 1st and 30th postoperative days, respectively.

We wish to present instances of chemical meningitis following spinal anesthesia.

### REPORT OF CASES

**CASE I.** A male university student, aged 20 years, an excellent general condition and nothing of importance, had left cephalic trepanotomy performed under spinal anesthesia on November 7, 1924. He received morphine sulfate 15 grains (hypodermically) 1 hour before surgery and epinephrine sulfate 1/100 grain (hypodermically) immediately before the lumbar puncture which was performed readily and without incident. There was no apparent trauma or hemorrhage. One hundred and fifty milliliters of novocain crystals dissolved in 4 cubic centimeters of clear spinal fluid was injected in the third lumbar interspace. Anesthesia to pin-prick was present to the 8th dorsal bilaterally 3 minutes after injection. Blood pressure, pulse, color and respiration remained unchanged, and the patient was comfortable and co-operative throughout surgery which lasted about 45 minutes. There was still some anesthesia present when the patient left the operating room.

Twelve hours after operation he developed throbbing headache which centered in the occipital region and radiated forward bilaterally. Accompanying these were nausea, vomiting, and photophobia. Twenty-four hours after operation the temperature was 102 degrees. The only neurological abnormality was cervical rigidity. Lumbar puncture revealed cloudy spinal fluid, with pressure of 70 millimeters of cerebrospinal fluid with normal dynamics. There was marked increase in cells, particularly lymphocytes, in the spinal fluid. Other laboratory findings are presented in Table II.

The headache was relieved by daily lumbar punctures with removal of spinal fluid, and had disappeared by the 1st postoperative day. Although there was no marked tenderness the stiffness of the neck persisted until the 3d postoperative day. By the 4th postoperative day the patient was very comfortable and symptomatic and was discharged apparently completely recovered one week later.

**CASE II.** A 33 year old female, weighing 156 kilograms, entered the hospital with a history of having had an old gonococcal infection of the pelvis which had been treated

From the Department of Surgery of the University of Chicago

# EDITORIALS

---

## SURGERY Gynecology and Obstetrics

LESLIE H. MARTIN  
Founder and Managing Editor  
1905-1935

---

LOYAL DAVIS, Editor

Isaac Lee  
SUMNER I. KOCH      MICHAEL I. MASON

---

DONALD C. BALFOUR, Associate, Editorial Staff

---

AUGUST 1943

---

### PLEURAL EMPYEMA

SINCE the principles of treatment that produce a high percentage of cure of empyema are not being widely applied in civilian practice and since war injuries of the chest so frequently result in empyema, a consideration of the modern management of this disease is timely. In spite of the best early management of war wounds involving the thoracic cavity and in spite of the early use of the sulfonamides many deaths and a great aggregation of chronically disabled soldiers will occur during and after this war, after the last war unless the cases of empyema are properly managed.

The frightful mortality of empyema during the influenza epidemic of twenty six years ago

not be surgically drained until pleural adhesions at the limits of the empyema cavity have become sufficiently firm to prevent collapse of the lung at the time a drainage tube is introduced. It was found that the pleural adhesions are sufficiently firm when the aspirated pleural fluid shows a sediment of approximately 75 to 100 per cent of pus after standing overnight. While the formation of firm adhesions is avoided the size of the empyema and the degree of toxic absorption from the pus should be reduced by partial aspiration of the pleural fluid every one or at most, every two days. Air should never be injected into a nontuberculous empyema because this prevents the progressive expansion of the lung and because the rise of air to the upper part of the pleural cavity actually creates an empyema space there. Surgical drainage should not be delayed beyond the recommended time since progressive fibrosis in the pulmonary and diaphragmatic walls of the empyema cavity delays or may even prevent obliteration of the empyema cavity by expansion of the lung and elevation of the diaphragm.

If it is assumed that surgical drainage is carried out neither too soon nor too late in the manner in which drainage is now practiced and continued until firm adhesions develop, whether the empyema is healed or not, whether it will remain as a source of future disability

spinal anesthetics. Previously over 500 spinal anesthetics had been administered without observing this complication. A different and experienced anesthetist administered the procaine to each patient. The same careful technique was employed throughout the series as to the sterilization of equipment and the method of administration. Lumbar puncture was readily and uneventfully performed in each instance. Both patients received novocain from 150 milligram ampuls and the drug, in a crystal form, was mixed with 3.5 to 4 cubic centimeters of clear spinal fluid before injection.

It is of interest that in the 2 patients presented in Table II there was an initial marked post-operative increase in the total protein content of the spinal fluid above the normal level of 30 milligrams per 100 cubic centimeters. There was an accompanying slight drop in the spinal fluid chlorides initially but this followed the protein in returning to a normal level in a few days.

In each subject there was a marked increase in the total cell count on lumbar puncture made 24 to 36 hours after operation. Lumbar puncture revealed cloudy spinal fluid with an increase in lymphocytes in our patients, and polymorphonuclear leucocytes, lymphocytes or monocytes in previously reported cases. Culture of the spinal fluid from our patients showed no growth on any media. An unsuccessful search was also made for a virus by injecting the spinal fluid subcutaneously in the foot pads of guinea pigs and intracerebrally and intraperitoneally in mice. The distressing symptoms of headache and pain on movement of the head were relieved in our patients by daily lumbar puncture and removal of 30 cubic centimeters of spinal fluid. This procedure also brought about a rapid decrease in the cell constituents, with the total protein and chloride content of the spinal fluid returning to normal levels. Our patients made prompt recoveries.

# SUMMARY

Two cases of chemical meningitis following novocain spinal anesthesia are reported and 8 additional cases following various spinal anesthetic agents are collected from other authors and reviewed. Four cases following simple lumbar puncture are reported which were taken from the literature.

Our patients recovered promptly after daily lumbar puncture and removal of spinal fluid. Of the 8 previously reported cases following spinal anesthesia 4 recovered and 3 died. The outcome was unknown in 1 instance. The 4 following simple lumbar puncture recovered from their meningitic symptoms.

It appears that chemical meningitis is an infrequent complication of spinal anesthesia, yet it behooves every surgeon and anesthetist to be cognizant of this rare complication and to see that the correct diagnosis is made and adequate therapy instituted. Apparently the incidence of this hazard is so infrequent that it should not deter the experienced anesthetist from employing this method of anesthesia when, after adequate consideration, it appears to be indicated.

# REFERENCES

1. ARVONIS, E. E. and MACC, S. *Ann Surg* 93: 93 939-944.
2. BROCK, S., BELL, A. and D. 1907 C. J. *Am. M. Ass.* 936: 66 44 445.
3. CAMPBELL, H. E. *Chinese M. J.* 935: 49 9-3.
4. DIXON, G. L. *Bull. Soc. nat. chir. Par.* 928: 54 996.
5. H. ELW, G. H. *Surg. Gyna. Obst.* 933: 57 700-703.
6. OGDEN, L. D. Reported mortality and morbidity following spinal anesthesia, American Society Regional Anesthesia, Scientific Session, March 3, 1936.
7. REYNOLDS, K. E. and WILSON, G. J. *Am. M. Ass.* 934: 62 460-462.
8. SELLER, W. G. and F. YVE, F. L. *J. Am. M. Ass.* 934: 8 95.
9. ZIMMERMAN, D. *Arch. Clin. Chir.* 900: 89 37.

costal muscles, the vital integrity of the suture line is safeguarded by immediate airtight, water-seal, dependent drainage of the pleural cavity. Such drainage has the additional important advantage of removing air that escapes from a wound of the lung, thereby preventing a tension pneumothorax. The

constant drainage of fluid produced by the trauma decreases the chance of the development of an extensive empyema and, if one does form, its severity will be lessened by the drainage that has already been instituted, and by early expansion of the collapsed lung.

JOHN ALEXANDER

represents the proper site for drainage in every case. The simplest way of determining the position of the floor is to aspirate from below upward in successive intercostal spaces until pus is found. In the horizontal direction the scapular or paravertebral line is the most dependent site for drainage while the patient is lying upon his back, but he will not lie upon his back when a drainage tube is pressed against the incision by the mattress. The posterior axillary line just free of the mattress is, therefore, the site of election for the insertion of drainage.

Intercostal drainage with a catheter or any small bore tube is an inefficient type of drainage. The small lumen of such tubes frequently becomes occluded by masses of fibrin and pus with the result that drainage of the empyema pus is obstructed. The pus then leaks out around the tube and air is sucked in around the tube air tight suction drainage thereby being lost. The use of a thumb-sized tube after the resection of a six centimeter length of a rib produces continuous drainage that will remain air tight indefinitely provided that the incision in the deep layer of the periosteum and underlying parietal pleura is only long enough to permit the snug introduction of the tube. The incision in the extracostal muscles need not be sutured and the incision in the skin should not be. The tube should not be fenestrated its inner beveled end should be placed just within the pleural cavity with the opening of the tube facing away from the diaphragm. If the tube is introduced too far pus will collect in the bottom of the empyema, and if the end of the tube does not reach the pleural cavity the tissues of the thoracic wall will gradually contract over the end of the tube and obstruct drainage.

The outer end of the long drainage tube should be put under water in a jar placed on

the floor. The evacuation of pus and air from the empyema cavity creates a negative pressure in the cavity which tends constantly to expand the lung elevate the diaphragm and obliterate the cavity. In cases in which expansion is unduly delayed the negative pressure in the drainage system can be greatly increased by some form of mechanical suction apparatus, the pressure of which is regulated by the introduction of an open tube for a variable distance beneath water in a control bottle. Such highly negative pressure drainage often cures a chronic empyema for which a Schede thoracoplasty would otherwise be necessary.

A final matter of great importance in the avoidance of a chronic empyema is the maintenance of the drainage tube in the entire thickness of the thoracic wall until the empyema cavity has become completely obliterated; only then should the tube be periodically shortened as the drainage track fills in from the bottom. The decreasing size of the cavity may be measured from time to time by the instillation of measured amounts of fluid, by exploration of the limits of the cavity with a stethoscope or if the residual cavity is small, by palpation with a finger when the cavity is represented by only a narrow and perhaps sinuous track. The instillation of iodized oil followed by the making of x ray films best reveals the extent of the empyema. When an empyema that has not already become chronic holds only thirty cubic centimeters of fluid negative pressure drainage may be dispensed with by cutting off the tube close to the skin.

Shell wounds of the thorax involving the pleural cavity and particularly the lung frequently result in empyema. When such wounds produce a sucking pneumothorax requiring débridement and closure of the opening in the thoracic wall by suture of the extra

costal muscles, the vital integrity of the suture line is safeguarded by immediate airtight, water-seal, dependent drainage of the pleural cavity. Such drainage has the additional important advantage of removing air that escapes from a wound of the lung, thereby preventing a tension pneumothorax. The

constant drainage of fluid produced by the trauma decreases the chance of the development of an extensive empyema and, if one does form, its severity will be lessened by the drainage that has already been instituted, and by early expansion of the collapsed lung.

JOHN ALEXANDER

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

IT is a great pleasure to review the new edition of Dr Curtis' book *A Textbook of Gynecology*. It can be stated without equivocation that it is the most satisfactory of all modern texts on Gynecology. Compact, clear, concise and beautifully illustrated, it is indispensable to the practitioner, the gynecologist, and to the surgeon doing gynecology. The text is very comprehensive and all subjects of importance are complete.

The illustrations are superb and the drawings of the pelvic fascias and muscle compartments, all the puzzle to medical students and more so to practicing gynecologists, are unique. For teachers the pelvic drawings and descriptions are invaluable. The illustration of the various somatic and sympathetic nerves, and the demonstration of the course of blood vessels should give each student many thoughtful hours of study. Dr Curtis, his assistants, and the artist—Tom Jones—have demonstrated to all of us many valuable lessons in the art of dissecting, of description, and of illustration.

In such a book few things should be criticized. I believe that although the drawings of the radical hysterectomy are clear and well done, the operation as described has little value. For simple total abdominal hysterectomy it is too radical for cancer of the endometrium, if one is to be radical, it is not radical enough and it is not nearly as extensive as it should be for the present conception of the Wertheim-Clark procedure. The latter operation will be done more and more in the near future and illustrations and descriptions of the dissection of the large vessels and the obturator foramen should be presented.

There is no mention of the importance of venograms and ligations of the deep and superficial femoral veins, or the external iliac veins in thrombophlebitis, or in patients with embolism. It is my impression that the treatise on gynecology the chapters on preoperative and postoperative care, except as it explicitly applies to the gynecologic patient, should be omitted. Inasmuch as gynecologic surgery is surgery, it is better that descriptions of the care of the patient be left to general surgical authors and that references to their works be sufficient for text of gynecology.

But for these few criticisms, and they are minor ones, this book is exceptional, and in the opinion of the reviewer Dr Curtis' book can be considered one of the important small volumes on this specialty.

JOE V. MEXIA.

U. S. TEXTBOOK OF GYNECOLOGY. By Arthur Hale Curtis, M.D. and Dr. Phauldaphen and London W. B. Saunders Co. 1941

THE new text, *Synopsis of Pathology* by W. A. D. Anderson, is a useful addition to the already numerous but not always adequate textbooks written for the student of medicine. In his preface the

author states that it was "intended to fill a gap which has existed between the very elementary manuals of pathology and the abundant excellent larger textbooks and reference works." The book is remarkable for the fact that in so much of its content it is strictly up to date. The bibliography which follows each chapter is brief, well selected, and most of the references are of recent date.

In its arrangement, the conventional pattern is followed. In the first 4 chapters the author discusses the subjects usually included in section on general pathology. Among these are included chapters on virus and rickettsial diseases and brief chapter each on chemical poisons and vitamin deficiencies. The remaining 4 chapters, disease processes are discussed by systems, e. g. cardiovascular system, kidneys, urinary tract and male genitalia, the lungs, etc. In the paragraphs on subjects which are more important from the clinical standpoint all essential data are included in abbreviated form but theoretical considerations, historical facts, and "medical mythology" are largely missing. Many short paragraphs on definitions and brief explanatory notes on the subjects of less importance or of rare occurrence are included.

The section on endocrine glands, like brief (37 pages and 36 illustrations) is especially well written and to the point. The chapter which follows on female genital organs is likewise excellent for the purposes of the medical student.

Illustrations are numerous (204 text illustrations and 7 color plates in 638 pages of text). The photomicrographs are generally good but many of the photographs of gross material are technically of poor quality. More than one half of the color plates are excellent.

This interesting, readable volume in pocket size should be attractive and useful to the medical student, intern or practitioner of medicine or surgery who wishes to refresh his memory and bring his concepts of disease processes in line with recently acquired knowledge.

F. D. GUY

THE material presented in *The Sexual Glands of the Male* has been assembled from the work of

ARTHUR H. P. WILSON. By W. A. D. Anderson, M.A., M.D. and Dr. Phauldaphen and London W. B. Saunders Co. 1941  
FROM SPECIAL LECTURES ON THE MALE. By Charles Brannan Lowrey, M.D., F.R.C. in collaboration with Frank Harrison, M.D. and Dr. Phauldaphen. (Reprinted from Oxford University Press, New York, London, Toronto, Oxford University Press, 1941)

several contributors to the *Oxford Tissue Leaf Urology*, under the editorship of Dr Lowsley.

Lowsley's chapters on the prostate gland cover most completely, but concisely, the embryology, anatomy, pathology, symptomatology, diagnosis and treatment—both surgical and medical. The discussion on embryology and anatomy is authoritative since the author has himself contributed much of the accepted information on these subjects. Modern concepts as to the etiology of prostatic hyperplasia and the added role of associated endocrine changes is well presented. The rôle of castration and the inhibitory effects of estrogen therapy on carcinoma of the prostate are adequately, but briefly, presented since this important subject is still in the stage of clarification.

Hinman and Smith have contributed an excellent survey of the embryology, anatomy, and physiology of the testes and epididymides. Diseases of these structures are considered in detail. The discussion on tumors of the testicle is most noteworthy as it brings up to date a subject in which the authors have made many contributions during the past 20 years.

The chapter of Gutierrez on the seminal vesicles, ampullae, vasa deferentia, and spermatic cord is a most exhaustive compilation of conditions which are only briefly discussed in most texts on surgery and urology.

Excellent illustrations by William P. Didusch add greatly to the value of the text.

This work can be heartily recommended to those who are especially interested in the sexual glands of the male.

VINCENT J. O'CONNOR

THE small volume by R. D. Langdale Kelham<sup>1</sup> on amputations and artificial limbs satisfies a real need in the armed forces and in the civilian doctor population because it deals adequately with the principles which underlie these subjects. The book contains less than a hundred small pages, but it holds all that a man in general practice need know upon the subject. Its organization of material brings out the important points with well defined clarity.

The main issues in amputations are not confused by irrelevant details. However, few details of any importance have been left out. The text is clear and readable. The illustrations of the operations and of the prostheses are line drawings which are simple but are well made. Their simplicity makes for easy recognition of the points that the drawings are intended to stress. Particularly is this true of the drawings which deal with the artificial limbs. The legends and sublegends are clear, and the captions on the drawings are fully explanatory. It is evident throughout that there has been full co-operation between the limb surgeon and the limb maker.

The authors very wisely have omitted any consideration of the specially named amputations, such

<sup>1</sup>AMPUTATIONS AND ARTIFICIAL LIMBS. By R. D. Langdale-Kelham, M.R.C.S., L.R.C.P., and George Perkins (MC), F.R.C.S., General Editor. The Rt. Hon. Lord Horder, G.C.V.O. London: Humphrey Millford (Oxford University Press) 1942.

as the Syme, Gritti-Stokes, Pirogoff, and so on. These operations have been outmoded, largely because of advances made in the limb makers' art.

Only the three major elective amputations in the upper and in the lower extremities have been described. However, many clinical features common to all amputations have been dealt with. The anatomy involved has been treated physiologically. Disarticulations have not been mentioned.

C. LATIMER CALLANDER

THE general practitioner to whom the volume *Indigestion, its Diagnosis and Management*<sup>2</sup> by Rehfuess is dedicated will profit greatly by the recorded precepts of this student of gastroenterology. Dr Rehfuess presents his thoughts on indigestion in an orderly fashion and by an attractive conversational method as might be used in clinical teaching. The term indigestion as used by the patient has been broken to a workable etiological basis and then the discussion of the several entities follows.

There are 29 chapters, two thirds of which are devoted to a discussion of these separate entities. Dr Philip Hawk contributed the chapters on vitamins and water metabolism. The chapters on history taking and examination of the patients, gastritis, peptic ulcer, and enteritis are excellent and could be read with profit not only by the general practitioner but by the undergraduate student of medicine. A substantial amount of space has been devoted to hepatobiliary disease thus giving the necessary emphasis to this very important subject.

There seems to be an overemphasis given to the details pertaining to food stuffs and not enough discussion to the why and wherefore of everyday practical diets. Furthermore, if this is a book for the general practitioner why the lengthy discussion in methods and technique of gastroscopy and roentgenology? The author's rules on feeding in carcinoma of the stomach and pancreatic disease and his "dietary precepts" are well presented and add greatly to the value of the book.

The organization and presentation of the material in this book reveal the independent thinking of a physician well grounded in research and clinical experience.

LOWELL D. SNORP

THE present war time need for knowledge of the subject of jaw and facial bone fractures makes the book written by Major and his collaborators<sup>3</sup> a timely contribution.

Well arranged, this book opens with a general discussion of fractures which is very complete, and it is gratifying to find stress placed upon the desirability of conservation in dealing with bone fragments, with consequent better results and lessened deformity. Diagnosis is ably presented and the ma-

<sup>2</sup>INDIGESTION, ITS DIAGNOSIS AND MANAGEMENT, WITH SPECIAL REFERENCE TO DIET. By Martin E. Rehfuess, M.D. Philadelphia and London: W. B. Saunders Co. 1943.

<sup>3</sup>FRACTURES OF THE JAWS AND OTHER FACIAL BONES. By Glenn Major, B.S., A.M. (Path.), M.S. (Exptl. Surg.), Ph.D. (Surg.), D.D.S., M.D., F.A.C.S. St. Louis: The C.V. Mosby Co. 1943.



teral on the displacement of fragments is much more complete in detail than is usual and anatomical drawings supplement the text.

Emergency treatment includes the neurological aspects of facial injuries and some exceedingly good advice is offered the general surgeon and the oral surgeon, relative to brain injury and shock.

The discussion of the various methods of inducing anesthesia leaves nothing to be desired.

The author rightly devotes considerable space to treatment. There is no departure from accepted procedures in reduction, or immobilization and fixation, but there is free discussion based upon sound pathological and physiological principles.

There is an expressed belief that the method used must be adapted to the case and great number of different approaches have been described and illustrated.

The criticism of some of the methods has been reasonable and generous. It is interesting to note that the use of extraoral fixation by means of screws and pins placed and held in fragments finds no enthusiastic endorsement.

A commendable feature of this book is the unusual attention paid to postoperative care and to complications. Too often these matters are treated perfunctorily.

Radiographic examination and the technique employed is presented in a simple and practical manner by one who understands the difficulties encountered in this field.

The discussion of war aspects of jaw fracture emphasizes the essential difference between civil and military practice.

This book is well written, concise and eminently practical. The subject matter is calculated to be of great interest and value to both physician and dentist, and it stimulates desirable understanding and co-operation in the care and treatment of these fractures.

F. EMERICK W. MARRIOTT

THE book *Endoscopic Prostatic Surgery* by Roger W. Barnes, is a 25 page monograph with 21 illustrations on a subject which could only be properly handled by a man with large clinical experience.

This is a timely discussion and among the first, as the procedure has not been in general use long enough to have an adequate discussion in all its aspects in one publication. It has real purpose in fulfilling supplementing those residents and younger urologists who are in the process of developing endo-

scopic prostatic technique. There is no substitute for clinical experience but a simple discussion, as herein presented, of all phases of this procedure makes it a very valuable one for those especially in their developing stages.

There is a chapter on the pertinent anatomical points connected with endoscopic surgery and attention is directed to the necessity of being competent and experienced cystoscopist before any attempt is made to become a resectionist and this is done obviously complete understanding and recognition cystoscopically of the various anatomical structures involved.

A well organized discussion on prostatism is presented with his personal indications and routine indications for surgical management for each type.

The routine examination of the patient with prostatism is taken up in great detail and could well serve as a guide for those not entirely familiar with this phase of prostatic surgery.

The author wisely states that his indications for resection may not be the same for all their surgeons, as this phase of the work must vary with each local urologist, but there is presented a full discussion of this subject which is fundamental and thorough. Work of this kind would not be complete without thorough discussion of the preoperative management of patients with prostatism as well as the meticulous care and detail necessary for their proper management after resection.

A complete discussion of the various anesthetics suitable for this operation is completely and sensibly discussed. There is enough history of the procedure in the work, as well as the development of various instruments in perfecting the procedure to satisfy academic interest although this has not been carried to the boring stage.

Without much doubt the section on actual technique with accompanying illustrations will be very helpful to those developing technique and gaining experience and could be used with value by many others presumed to have developed technique.

The author is to be congratulated upon his honest discussion of the various pitfalls of the procedure and the complications resulting not infrequently from endoscopic prostatic surgery. This chapter alone in conjunction with postoperative care could be carefully scrutinized with benefit by any urological surgeon regardless of his experience.

This is a very timely monograph. Well organized, simply presented, and should have a real place in the development of younger men in the field of endoscopic prostatic surgery.

HARRY C.

# SURGERY

## GYNECOLOGY AND OBSTETRICS

*An International Magazine, Published Monthly*

VOLUME 77

SEPTEMBER, 1943

NUMBER 3

### OBLIQUE, ASEPTIC, END-TO-END ILEAC ANASTOMOSIS, PROCEDURE OF CHOICE IN STRANGULATING SMALL BOWEL OBSTRUCTION

CLARENCE DENNIS, M D, Minneapolis, Minnesota

UNLESS there is a compelling contraindication, most surgeons prefer exteriorization to resection and the performance of primary anastomosis in the presence of strangulating obstruction of the small intestine. The chief compelling indication for a primary anastomotic procedure instead of exteriorization has been considered a high situation of the lesion, a situation in which intestinal fistula is definitely hazardous.

During the past 2 years, resection and primary anastomosis have become the procedure of choice at the University of Minnesota Hospitals in the management of small intestinal obstruction complicated by the presence of nonviable bowel, either from strangulation or other cause. This procedure started with an infant of 5½ weeks who recovered after resection of a gangrenous intussusceptum, a procedure performed with a background of experience with end-to-end anastomosis in dogs. In subsequent cases patients have been treated in similar fashion, until now 16 consecutive cases (15 patients) have been treated in this

manner, with 2 deaths. In similar groups of cases in which older methods were used, the mortality rate has been reported at varying levels from 30 to 50 per cent (6, 15).

#### TECHNIQUE OF ANASTOMOSIS

The type of procedure used in most of these cases is an oblique, aseptic, end-to-end anastomosis, a modification of that described by me 4 years ago (1), which is in turn a modification of that of Martzloff and Burget (8). One of the chief difficulties which this procedure is designed to overcome is the end-to-end union of segments of widely differing diameter without the formation of blind pockets, kinks, etc. In order to clarify presentation, the details of the procedure as now used will be presented at this point.

The mesentery is meticulously cleaned from the distended bowel proximal to the point of obstruction, a site close to the point of approach of large vessels in that mesentery being chosen (Fig 1). A slender, crushing, anastomosis clamp is placed across the bowel, from the antimesenteric border, at an angle of about 75 degrees from the long axis of the gut. The clamp crosses the mesenteric border about 6 millimeters below the edge of the unremoved mesentery.

From the Department of Surgery, University of Minnesota.  
The researches presented here were supported by a grant of the Graduate School of the University of Minnesota and by a grant for technical assistance by the Work Projects Administration. Official Project No. 165-1-71-124. Subproject No. 399.



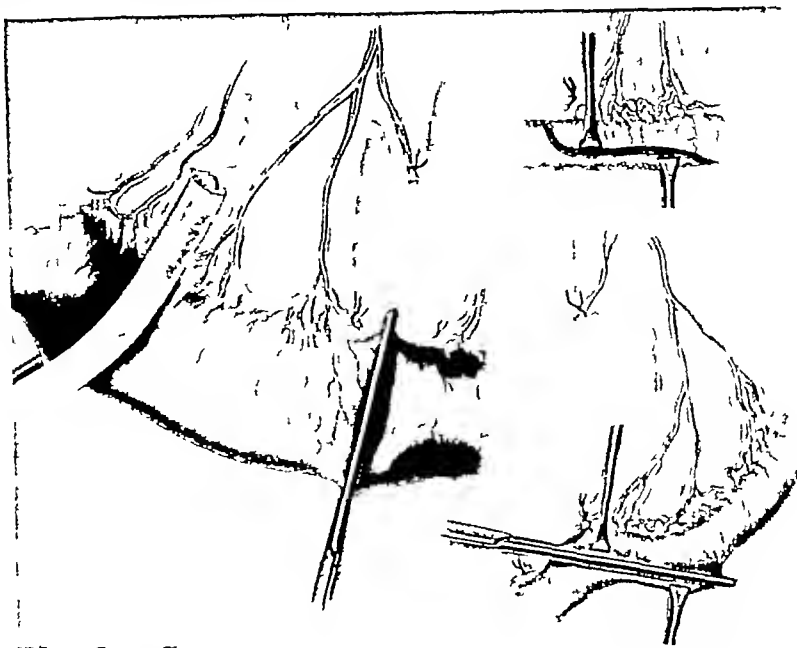


Fig 1

Fig 2 and 2a, above

Fig 1 Placement of the first anastomosis clamp on the distended bowel above the point of obstruction. The clamp crosses the bowel at an angle of 75 degrees and at the mesenteric border about 6 millimeters from the edge of the unremoved mesentery. The bowel has been milked back and a rubber shod clamp is applied to prevent spillage.

Fig 2 Placement of the second anastomosis clamp on the contracted bowel below the point of obstruction. The line of crush begins 6 millimeters from the unremoved mesentery, crosses obliquely  $\frac{2}{3}$  of the bowel and passes for a distance parallel with the antimesenteric border before crossing the remaining  $\frac{1}{3}$  of the bowel, a. This length of crushed tissue, equal to that in Figure 1, is obtained by distorting the bowel with Allis forceps. This clamp is placed from the mesenteric border.

placed, the silk sutures are tied, and the anastomosis thus completed.

To close the mesenteric defect, a stitch near the center of the posterior suture line is threaded on a needle and a small bite of each mesenteric edge is taken 3 centimeters from the bowel (Fig 9), and behind it, and thus the defect in the mesentery is tied. From this point to the root of the mesentery, interrupted silk sutures are placed. Efforts to cover the suture line with omentum have been abandoned as useless. Sulfonamides have not been generally implanted into the peritoneal cavity because it has seemed that this procedure leads to excessive adhesion formation.

The clamps used in making this anastomosis differ from those of Martzloff and Burget (8) in that they are shorter and lighter (Fig 10). With the shorter clamp one may

rely less on the springiness of the instrument to crush the tissue at the tip, and the clamps may therefore be more easily removed during the anastomosis. Deep, sharp, longitudinal, matching grooves are cut on the jaws of the clamp.

The advantages of this type of anastomosis over many of those described in the literature have been discussed in a previous paper (1). Certain advantages will be emphasized at this point.

1 End-to-end anastomosis avoids the formation of the blind pouches which result from closure of both ends and side-to-side anastomosis.

2 End-to-end anastomosis necessitates but one suture line, whereas closure of the ends and side-to-side anastomosis requires three lines.

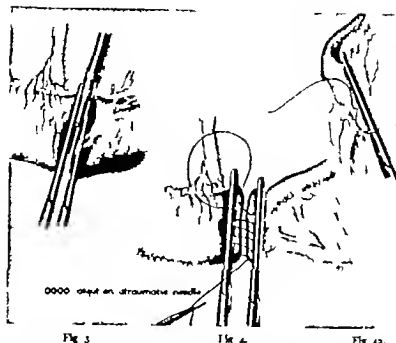


Fig. 3

Fig. 4

Fig. 4a

Fig. 3. Casting the bow of between the clamps described in Figure 3 and Figure 4b the catgut. To prevent spillage additional clamps are placed between those applied for anastomosis and the specimen to be removed.

Fig. 4. Placement of the posterior running fine catgut suture. The clamps are held side by side so that the bow of each are brought together. 4b. 80 degrees rotation of one 4b respect to the other. The suture is laid 4b the clamps rolled away from each other as shown. The bites are 5 millimeters long and the gaps between bites are 4 millimeters. a. Placement of each end bite parallel to the long axis of the gut assures good inversion later.

3. Aseptic procedure permits apposition of serosal surfaces uncontaminated with luminal contents.<sup>1</sup>

4. Obliquity of placement of clamps permits the best possible blood supply to the line of suture for the vessels follow a circular course around the bowel and are not, therefore, interfered with before reaching the suture line.

5. Rotation of one segment of bowel with respect to the other minimizes angulation and therefore minimizes possibility of obstruction at the point of anastomosis, as shown in Figure 11.

6. Rotation of the bowel avoids the dangers of closure without peritoneum at the

The experimental data presented illustrate that point only fairly well because of the small number of eyes examined, but comparison of the results here reported with those of Orange and Smith, who used open procedure exclusively, furnishes abundant evidence in favor of the present procedure.

mesenteric border in other words, by this rotation peritoneum is provided on one surface or the other completely around the line of inversion.<sup>2</sup>

7. This type of anastomosis avoids the danger of stenosis at any time in the post-operative period. There has been no case of dysfunction secondary to the quarter twist imposed on each end to be anastomosed.

#### CLINICAL CASES

On 16 occasions between November 1, 1940 and March 1, 1943, nonviable segments of small intestine have been resected in the presence of small intestinal obstruction. These are consecutive cases, no patient with gangrenous bowel and obstruction having been

In over 100 clinical cases and 10 experimental anastomoses, no instance of leakage at the ends of the suture line, or at the mesenteric border on our side, has occurred.

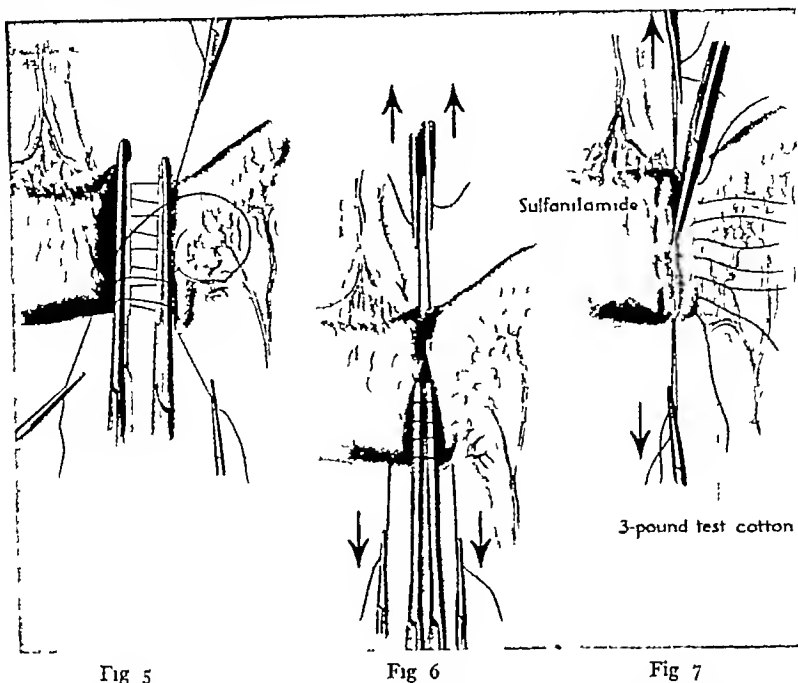


Fig 5

Fig 6

Fig 7

Fig 5 Placement of the anterior running catgut suture. The clamps have been rolled together.

Fig 6 Removal of clamps. Tension is applied to the two ends of each of the running sutures, the clamps are carefully loosened until the tips are spread 1 or 2 millimeters and the clamps are cautiously and simultaneously removed.

Fig 7 Reinforcement of the suture line. The ends of the posterior running stitch have been tied to the corresponding ends of the anterior strand and tension has been maintained during placement of Halsted mattress sutures of 2½ pound silk. With the latter placed, but not tied, sulfanilamide is applied in small amounts between the serosal surfaces to be approximated by them.

denied operation. There have been 2 deaths, a patient mortality of 13.3 per cent and a case mortality of 12.5 per cent, levels no different from the mortality for intestinal obstruction as a whole at this clinic (2). The cases are summarized in Table I. More detailed summaries of 6 cases are included to illustrate special points.

Patient No. 1 U H 702210, male, aged 39 days, was admitted November 20, 1940, in a dehydrated state with a 60 hour history typical of intussusception. The abdomen was tympanitic and too distended to allow palpation of a mass, which could, however, be felt high on the right on rectal examination. He was transfused and given 100 cubic centimeters of 0.9 per cent sodium chloride solution before operation, and was slowly transfused during the operation. Through a right lower rectus incision, an ileocolic intussusception was identified, and the apex was milked back into the ileum, but the lesion could not be completely reduced despite considerable

manipulation, efforts were terminated by occurrence of a serosal tear. The upper margin of the intussusciens was observed at this point to be discolored, edematous, and firmly sealed to the bowel above it. The apex could be pushed about 2½ centimeters above the ileocecal junction. The involved area was resected from this point to a site 5 centimeters above the upper margin of the intussusciens, and an aseptic, end-to-end anastomosis of the Martzloff-Burget type was performed with catgut used for the internal layer. About 1 gram of sulfanilamide was implanted, partly about the anastomosis and partly in the wound during catgut closure.

After operation the patient was given 100 per cent oxygen, nasal gastric suction was used, and sodium sulfathiazole was given intravenously for 36 hours. Feces were passed at 48 hours, and the temperature reached normal at 72 hours. Early feeding was cautious, but the patient improved rapidly and was dismissed 22 days after operation. He was last seen 4 months later, and seemed a normal baby at that time.

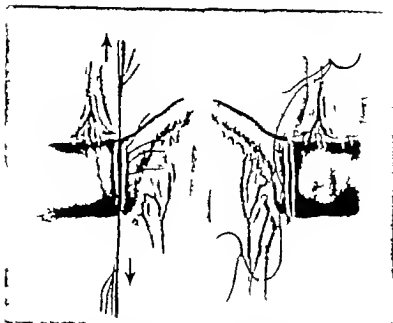


Fig. 8.

Fig. 9.

Fig. 8. Tying of the flapped mattress sutures, with maintenance of tension on cat gut strands. The posterior side is treated in similar fashion.

Fig. 9. Rear view of anastomosis, showing placement of stitch to close the mesenteric defect.

The specimen presented areas of necrosis and there was hemorrhagic infiltration of the gut wall.

Patient No. 3. U. I. L. 64765 female aged 7 years as admitted March 24, 94. 24 hours after an old umbilical hernia had become incarcerated. Pain had become severe and constipated, and vomit was profuse. Examination showed hernia the size of a man's head. It was very tender to touch, and the entire abdomen tender and silent. Temperature was 98 degrees.

At operation the patient went into profound shock as soon as the transverse skin incision had been made. Following transfusion of blood and plasma the pulse became perceptible and gradually improved. The hernia contained some colon, the cecum, the appendix, and much of the ileum. When the hernial ring was cut, the color returned to most of these organs, but 5 centimeters of upper ileum remained black and nonmotile. This segment was resected, and oblique, aseptic end-to-end anastomosis with implantation of sulfanilamide as performed. The hernia was repaired with silk, with great difficulty because of tension.

After operation nasal suction was used for 5 days and patient did nicely except for senile confusion and moderate wound infection. She was followed after discharge, and the hernia recurred 8 months later.

The specimen showed hemorrhagic infarction of the bowel.

Patient No. 5. U. I. L. 648767 female aged 53 years as admitted May 7, 94. The patient had had many previous operations, one for adhesions. She was admitted after 48 hours of nausea and severe colicky abdominal pains. On admission to the hospital there were borbororygmi with typical cramps. Within 48 hours she developed bilateral tenderness and rebound tenderness, and the temperature rose to 100 degrees. She was, therefore, subjected to exploration.

At operation through left lower rectus incision, 5 centimeter piece of ileum was found herniated beneath adhesive band running from the dome of the bladder to an old subumbilical scar. This bowel was black, and was, therefore, resected and primary oblique, aseptic, end-to-end anastomosis performed with implantation of total of 4 grams of sulfanilamide. Because of the marked distention catheter enterostomy was performed proximal to the suture line. Because there was drop in blood pressure late in the procedure the wound was closed rapidly with running suture of catgut.

This is the only case in the present series in which this procedure was taken.

Catgut closure has been used on 4 intestinal anastomoses cases because of the poor condition of the patients (Case 1, this case, and case without reaction). Two of the three developed hernias. In case in which heavy silk was used (Case 11, because of large hernial defect, hernia developed in this wound. In most of the remainder, neither with gas problems known or not, fine silk has been used in the incision, and no wound complications have developed except in case there was protrusion and in another superficial infection. Case 12.

Nasal suction was discontinued in 6 days, the patient was dismissed in 15, and the enterostomy tube was withdrawn in 10 days.

Examination of the specimen showed hemorrhagic infarction.

The patient was thrown from her seat in an automobile accident on her way home and developed immediate pain in her wound, followed by hernia formation. A year later, because of pain, this hernia was repaired. The ileum for a total of 70 centimeters above and below the old anastomosis was densely bound to the scar by scar tissue and was, therefore, removed. reanastomosis was performed as before. The patient has apparently been cured.

The pathology report on this second specimen reads:

At approximately the midportion of this intestine there is an oblique suture line with slight thickening of the peritoneal surface and induration. The circumference of the bowel along this suture line (measured on the mucosal surface) is 8.5 centimeters. The circumference measured directly transversely is 8 centimeters. The circumference 4 centimeters above the suture line is 8.4 centimeters and at 0.4 centimeters at a point 4 centimeters below the suture line. This is an old suture line with no signs of the sutures being found. There is no evidence of leakage. On cross section an annular rim or tissue follows the line of previous sutures (Fig. 17).

Patient No. 7, U. H. 713320, female, aged 75 years, was admitted September 20, 1941. The patient presented a 5 week history of cramps relieved by defecation. Twenty hours before admission she developed severe abdominal pain, nausea, coffee ground vomiting, and loose stools. She had lost 30 pounds in a month. The patient had a history of heart failure and she had arricular fibrillation on admission. She presented signs of peritoneal irritation, and a cauliflower like mass could be felt on pelvic examination. Temperature was 98.6 degrees, white blood count 15,000. With the possibility of peritonitis from a ruptured appendix in mind, the patient was treated conservatively for 12 hours, then return of blood through the nasal suction tube led Dr. Iyle J. Hay (then resident in surgery at the University of Minnesota Hospitals) to diagnose mesenteric vascular thrombosis and explore the abdomen.

At operation the small intestine was found gangrenous except for 10 centimeters above and 60 centimeters below. Resection with primary aseptic anastomosis was performed by the Martzloff Burget method.

After operation the patient was rapidly digitalized, and the pulse became regular. The nasal suction was discontinued 7 days after operation, but temporary stomal obstruction thereafter marred the convalescence for some days. Diarrhea was troublesome for a short time after recovery, but the patient was

<sup>1</sup> These data indicate that the crushing of tissue in the anastomosis clamp does not lead to subsequent contraction of the line of suture. For the length of the area of crush at the first operation was 5 centimeters on the serosal surface.

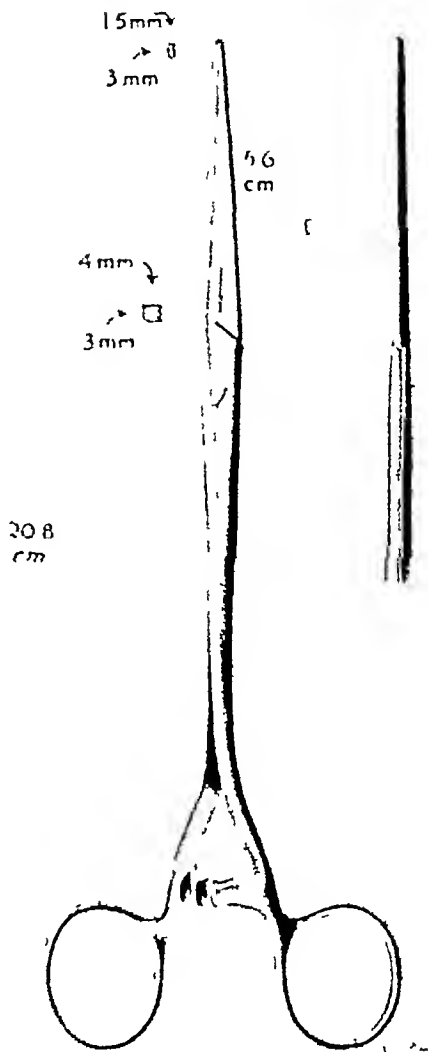


Fig. 10 The anastomosis clamps

dismissed 26 days after surgery. She failed all her return appointments and stopped taking her digitalis.

The specimen was 175 centimeters long after fixation, and of this, 80 centimeters was gangrenous due to mesenteric arterial thrombosis.

Patient No. 7 (second resection). This patient was readmitted October 12, 1942, after 19 hours of vomiting, cramps, and severe abdominal pain felt also in the back. With the limited length of small bowel remaining after her first resection, she had maintained excellent health, had had a voracious appetite, and had lost but 3 kilograms in a year. On



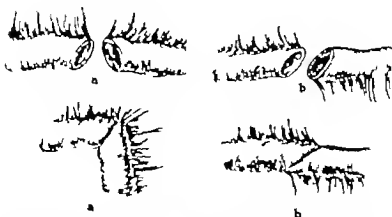


Fig. 2. a, Schematic drawing to illustrate the angulation resulting from end to end anastomosis of bowel cut at 45 degrees and apposed without rotation. b, The obliteration of angulation accomplished by rotation of one segment with respect to the other is apparent. (Reprinted from *Surgery* 1939, 5: 543)

this 3d deconvulsion, the abdomen presented signs of marked peritoneal irritation, motion of the turgor was very painful, the gastric aspiration was bloody and the electrocardiogram showed irregular fibrillation. Gangrene of the remaining small bowel diagnosed and the patient was rapidly (5 hours) digitalized, hydrated, and laparotomized.

At operation the remaining jejunum and ileum were found gangrenous and the abdomen contained fecal-appearing green fluid. The circulation to the cecum and descending colon seemed degenerate. The ligation of Treitz and the lateral peritoneal attachment of the cecum and ascending colon were severed to allow approximation of the terminal duodenum and ascending colon and an aseptically end-to-side anastomosis was performed, with inversion of the stump of the ileum. A total of 6 grams of sulfathiazole was implanted. Closure of the abdomen was made with steel.

On the 4th day after operation, the patient developed right saphenous thrombophlebitis (this responded nicely to procaine lumbar sympathetic block). On the 7th day the patient developed pulmonary edema, probably from excessive fluid administration (she gained to 57 kilograms from the initial dehydrated level of 53.6 kilograms). Positive pressure of 8 millimeters of mercury was applied by using neoprene mask and mixture of bellows and oxygen after 4 hours of such administration for 20 minutes every 4 hours, she appeared to have recovered, became mentally alert and took cream of wheat by mouth. On the afternoon of the 8th day she had an attack of cyanosis followed by stupor and apparent calcareous of the left arm. Oxygen was administered. She did not again improve and although the abdomen remained soft and bowel movement continued, she lost strength, had repeated attacks of cyanosis, and died 9 days after operation.

After removal of the nasal suction tube 4 days after operation, it was observed that ingested food usually was passed in still recognizable form in less than a half hour.

The specimen removed at operation consisted of 3 centimeters of small intestine as measured in the fresh condition. Thrombi were present in both arteries and veins, and the bowel was gangrenous throughout and but 3 to 6 centimeters at each end.

A autopsy revealed clean abdomen. The suture line anteriorly as covered by omentum. When this was removed, the suture line could be pulled apart with very little tension, and small abscesses found between mattress sutures (a point at which there had been bouts of spillage during the anastomosis). The mucosal surface of the line of anastomosis showed more ragged and necrotic appearance than usual at this stage. On the left of the colon opposite the duodenocolostomy, large deep ulcer (5 by 7 cm.) as present. The remaining ileocolic vessels and the main trunk of the superior mesenteric vein were filled with large fresh thrombus. The mitral valve showed subacute bacterial endocarditis with fresh vegetations and fresh infarcts were found in the kidneys, spleen and brain.

It would seem that this patient was lost not through any inherent defect in the anastomotic methods under discussion but rather because the necessary resection exceeded in magnitude the limit which one can tolerate and because of a complicating bacterial endocarditis.

Patient N. L. H. 78626 female, aged 68 years, admitted March 9, 1941. There was a 36 hour history of irreducibility of old left lower

This is the only case in the series in which there has been evidence of propagation of thrombus after resection of gangrenous bowel.

TABLE I—SUMMARY OF CASES

Patient No	Age	Type of obstruction	Duration	Length resected cm	Type of anastomosis	P O duration of suction	Outcome	Length of hosp stay days
1*	39 da	Intussusception	60 hr	8	Martzfloff Burget†	36 hr	Well	22
	8 yr	Volvulus—enteric cysts	36 hr	45	Oblique aseptic	4 days	Well	12
3	71 yr	Ventral hernia	48 hr	125	Oblique aseptic	5 days	Well	21
4	46 yr	Ventral hernia (Richter)	72 hr	30	Oblique aseptic	6 days	Well	11
5*	53 yr	Internal hernia	48 hr	50	Oblique aseptic	6 days	Well	15
6	24 hr	Vascular occlusion	2 weeks	60	Martzfloff Burget‡	5 days	Well	13
7	75 yr	Vascular occlusion	20 hr	175	Martzfloff Burget‡	7 days	Well	26
Second admission 1 yr later								
	76 yr	Vascular occlusion	24 hr	Rest of jejunum and ileum	Aseptic end to-side duodenocolostomy	4 days	Died	9
8	11 mo	Intussusception	40 hr	10	Martzfloff Burget‡	56 hr	Well	24
9	53 yr	Adhesions and vascular occlusion	60 hr	34	Aseptic end to-end ileocolostomy	6 days	Well	14
10*	68 yr	Femoral hernia	41 hr	50	Oblique aseptic	4 days	Well	21
11	47 yr	Vascular occlusion	40 hr	40	Oblique aseptic	5 days	Well	14
12*	55 yr	Femoral hernia (Richter)	10 days	10	Oblique aseptic	6 days	Died	19
13	50 yr	Femoral hernia	16 hr	10	Oblique aseptic	3 days	Well	12
14	69 yr	Vascular occlusion	5½ days	72	Aseptic end to-end ileocolostomy	5 days	Well	9
15	57 yr	Inguinal hernia	36 hr	30	Aseptic end to-end‡ ileocolostomy	5 days	Well	12

\* Additional data in case summaries in the text

† The procedure here used differs from that of Martzfloff and Burget in that the internal running stitch has always been catgut not silk

‡ Procedure by Dr A. J. Kremen, fellow in surgery at the time now in the armed forces

§ Procedure by Dr Lyle Hay, fellow in surgery at the time now in the armed forces

¶ Procedure by Dr Bernard G. Lanfin, resident in surgery

quadrant hernia, with abdominal cramps, lumbar pain, and vomiting. On examination the positive findings were auricular fibrillation, hypertension, a left lower quadrant hernia, 16 by 10 centimeters and bluish discoloration of the skin over the hernial protrusion. The abdomen was silent.

At operation, incision as for Bassini hernioplasty revealed the hernia to be femoral. An accessory vertical incision was made over the sac, forming a T incision. Ileum was found entering and leaving the neck of the sac, and exposure down to the sac permitted visualization through the wall of the sac of black bowel and blood black exudate. At the suggestion of Dr R. L. Varco,<sup>1</sup> then resident on surgery, the bowel was cut between clamps as it entered and left the sac, and the sac itself was excised intact and without contamination of the wound with the contents. An oblique, aseptic, end-to-end anastomosis with implantation of about 100 milligrams of sulfathiazole was accomplished, and the necessarily severed inguinal ligament and the hernial defect were repaired with 5 pound test silk.

After operation the patient was rapidly digitalized, and the pulse became regular. Nasal suction was

<sup>1</sup> This is to be reported separately.

used 4 days, and a soft diet was allowed at 6 days after operation. A superficial wound infection delayed dismissal of the patient until 3 weeks after operation.

Inspection of the hernial sac showed the content to consist of 30 to 40 centimeters of gangrenous bowel and some omentum.

This method of dealing with hernias containing dead bowel and free fluid offers promise of saving a certain number of patients who have in the past been lost. It would have improved chances in Case 12 if she had come a few hours earlier.

Patient No 12 U H 721428, female, aged 55 years, was admitted June 3, 1942. This patient presented a 10 day story of illness beginning with sudden severe abdominal pain, continued vomiting and cramps, and finally 6 days of conservative therapy with nasal suction and intravenous fluid administration at a local hospital. The patient was transferred to the University Hospitals on the day abdominal tenderness and fever appeared. Examination

showed a flaccid abdomen rather tender to deep pressure but the patient arrived here well sedated. The abdomen silent except for rare gurgles there were no cramps. No hernia were found on careful search. Temperature 38.1 degrees white blood count 10,000 blood urea nitrogen 59 milligrams per cent.

Attempts to pass a Miller Abbott tube were not successful. I doubt for a definite diagnosis, 24 hours was allowed to pass in order to establish better hydration before exploration. With the patient still clouded mentally and the temperature over 3 degrees by rectum, operation was order taken.

The serosal surfaces are a gray red appearance the upper ileum was distended to 6 centimeters in diameter. Fecal material was found on the serosal surfaces in the right lower quadrants, emanating from Richter hernia into the femoral canal. Adjacent to the ring, the bowel had perforated leaving a fibrin-covered rent. The sac was curetted and drained extraperitoneally after it had been packed with sulfathiazole and the peritoneal defect had been closed. The involved bowel was resected and an oblique aseptic end-to-end anastomosis was made with implantation of sulfathiazole. The abdomen was closed with running No. 20 day chromic catgut with further sulfathiazole implantation.

The patient failed to recover consciousness. Despit good urinary outputs (10 to 15 liters) the uremia progressively deepened. Twitching of one side of the face occurred, suggesting cerebral accident. Wound infection and dehiscence to the peritoneum occurred and the patient died 9 days after operation. For the last week he was fed by drip feedings through an indwelling nasal gastric tube.

Postmortem examination showed general peritonitis, most severe in the region of the right femoral canal. The anterior line of anastomosis was found to leak mildly between the mesenteric and the anti-mesenteric borders. Examination of the specimen implied inadequate space between the lines of suture. Permission to examine the brain could not be obtained.

At the time of the performance of this anastomosis effort was being directed to the inversion of as little tissue as possible and to the placement of the two rows of sutures very close together a policy which has now been dropped.

#### THE SURVIVAL OF DOGS FOLLOWING ANASTOMOSES BY VARIOUS METHODS AFTER ILEAC OBSTRUCTION

The literature does not contain many favorable references to the application of primary anastomosis of any kind to cases of small bowel obstruction. Owings and Smith published experimental results indicating that

primary open, side-to-side anastomosis is feasible after resection of all bowel which is either distended nonresponsive to stimuli which normally cause contraction in the dog or which does not offer normal resistance to the passage of a suture needle. They had a considerable mortality although it dropped to zero in the last group of dogs in which they performed very extensive resections. They did not apply the method to clinical cases. Aside from this article the author has not found any serious discussion in the literature of application of primary anastomosis as a procedure of choice in obstruction with non-viable or doubtfully viable bowel.

**Procedure.** In order to test the feasibility of primary anastomosis in the presence of obstruction in dogs and also to evaluate one anastomotic method against another a series of experiments was performed on 28 dogs. Adult male dogs of about 40 pounds were routinely used. About a half hour before anesthesia,  $\frac{1}{4}$  to  $\frac{1}{2}$  grain of morphine sulfate and  $\frac{1}{50}$  grain of atropine sulfate were given subcutaneously. Following ether induction, a soft rubber intratracheal tube was placed and rendered tight by securing the mouth about the tube. A very constant level of anesthesia was maintained by use of a standard laboratory ether bottle. A left rectus incision was made and the ileum 25 centimeters above the ileocecal junction was divided between clamps the ends being phenolized, alcoholized and inverted with a Parker Kerr No. 40 commercial cotton suture (11). Closure was secured with 3 interrupted Halsted mattress sutures of the same material. The latter sutures were used to tie the inverted ends together as a precaution against intussusception and the abdomen was closed in layers.

The dogs were returned to a room in which the temperature was held between 80 and 85 degrees F. a precaution which cut the loss from pneumonia from 50 per cent almost to zero. Following obstruction fluid was supplied intravenously in the form of 0.9 per cent sodium chloride 750 cubic centimeters being given twice daily.

At an interval of days after obstruction the animals were given 0 to  $\frac{1}{4}$  grain of morphine sulfate and  $\frac{1}{100}$  grain of atropine sul-

fate, and anesthetized as before with ether. Through a right rectus incision the area of obstruction was delivered, and anastomosis was performed in one of 3 ways (1) open, side-to-side, with 2 rows of No. 00 catgut to short-circuit the fecal stream without resection, (2) oblique, aseptic, end-to-end anastomosis, as described earlier in this paper, but without sulfonamide implantation, or (3) oblique, aseptic, end-to-end anastomosis with implantation of a total of 60 or 70 milligrams of sulfanilamide in the interval between the suture lines. The dogs were regularly given isotonic sodium chloride solution intravenously the day of operation, water by mouth the 2d day, milk the 3d, and horse meat and mixed table scraps were given from the 4th day.

*Experimental results.* The dogs usually vomited 48 hours after obstruction, and the vomitus usually became fecal in character in 72 to 120 hours. Frequently the abdomen became distended.

Eight dogs died after obstruction and before anastomosis. Two of these were obstructed in the presence of diarrhea, and died of chemical imbalance which was not understood. Two died of perforation at the site of obstruction, the first had been obstructed by division and double pursestrings, a procedure which was therefore abandoned, the other bowel perforated through a suture hole which was evidently placed too deep. One died of pneumonia, 1 of an abscess resulting from subcutaneous instead of intravenous fluid administration, and 1 died of intussusception of the whole site of obstruction as far as the pelvic colon. Finally, 1 dog was used as a control, and survived 12 days, the abdomen being clean at autopsy.

The second operation was undertaken, as a rule, after 5 to 7 days of obstruction, but there were 2 instances in which this interval was 8 days, 3 of 4 days, one of 3 days, and one of 2, all these survived.

Careful notes of the condition of the distended bowel were made at the time of most of the anastomotic procedures. In the 4 to 8 day group of animals, the ratio of the diameter of the bowel above the obstruction to that below ranged from 2 to 5.2, with a mean

of 2.7 times. The actual diameter was at times as great as 6 centimeters. As Owings and Smith observed, the bowel above the obstruction usually had an edematous appearance. In 8 of the 9 instances in which definite mention was made of the color of the bowel, it was described as discolored or cyanotic. In 2 additional cases the bowel was gangrenous, 1 with a frank perforation sealed by the omentum<sup>1</sup>, in each of these instances the gangrenous areas were resected with a margin of less than 10 centimeters, and both recovered.

In all the 4 to 8 day group, the proximal bowel offered much less resistance to the passage of the needle than the distal bowel, and sutures could be tied only tight enough for apposition, lest they cut into the edematous proximal bowel wall. In the majority of instances, pinching of the bowel just proximal to the site of suture line failed to evoke contraction of the musculature.<sup>2</sup> If such a segment is tested for bursting strength, it is found to be greatly weakened below the normal level of 450 to 550 millimeters of mercury. In 9 instances in which this was checked, the mean bursting strength was 209 millimeters, the minimum was 72 millimeters and the maximum 320 millimeters.

Following reanastomosis in the successful cases, profuse diarrhea was usually observed within an hour or two. Water was usually taken the same day, and food as soon as it was offered.

From the point of view of survival, those animals which returned to a full diet and in which subsequent examination of the specimen revealed a firm anastomosis with adequate stoma were considered satisfactory, a few of these were lost in an epidemic of distemper, and some were lost in a heat wave. Those which failed to achieve normal gut function were considered failures, with the exception of 1 dog with an open and 1 dog with a closed anastomosis, which died 1 day after surgery in the heat wave which killed also some unused stock animals, these have been included as satisfactory anastomoses because

<sup>1</sup> This dog had been obstructed 8 days. In this animal and in one 5 day experiment the author had the privilege of testing the aseptic decompressing device devised and reported by Wangenstein (13) prior to the application of it to clinical cases. It was also used in Patient No. 9, Table I.

<sup>2</sup> These changes also were observed in almost all the clinical cases.

they looked excellent at postmortem examination and did not seem to have contributed to death. One dog was kept open over 2 hours on a cool day for photographs and died of atelectasis within a day—this was omitted.

The results of these experiments are summarized in Table II.

TABLE II.—ANASTOMOSIS IN THE DOG FOLLOWING ILEAC OBSTRUCTION

Type of anastomosis	Number of dogs	Unsatisfactory		Satisfactory	
		Leakage	Obstruction	Number	Per cent
Open side to side					25
Oblique, mesic, and-to-end without infundibula	6				
With infundibula	10			10	100

This obstruction was partial and contributed to death 1 day after operation.

This resulted from clamping at operation, but led to hemorrhage near the suture line, necropsy of blood supply evident.

#### THE HEALING OF ANASTOMOSES PERFORMED ON BOWEL WHICH HAS BEEN SUBJECTED TO DISTENTION AS A RESULT OF OBSTRUCTION

Halsted devised an open end to-end anastomosis performed with presection sutures. He pointed out several dangers which have been applied to anastomosis in general (1) overinversion of tissue causing either obstruction to the lumen or necrosis of the inverted tissue or even necrosis at the suture line from tension (2) too shallow placement of sutures, with inadequate grip and consequent tearing of the tissues leading to loosening of the closure and peritonitis and (3) too deep placement of the sutures, forming a tract through which peritonitis was observed to develop.

Halsted's specimens were studied microscopically by Mall who confirmed the dangers of including mucosa in silk sutures, and observed a cyst like adenomatous growth of mucosa through all but the serosal layers when this was done. In sections made 1 to 2 days after anastomosis pus cells were frequently found in considerable numbers between the apposed surfaces. The mucosa did not become fully regenerated until about 3 weeks. He concluded that the inverted ridge or flange of tissue begins to unfold at about 4 weeks

and eventually unfolds to leave only an area of slight thickening.

Further studies by Holman and Sabin on anastomoses made by Halsted's technique corroborate the earlier findings in most regards but in these later observations the mucosa healed completely in 9 days. Some of the published plates show no disappearance of the inverted flange after 10 weeks.

Martaloff, Moore and Gardner (9) studied the healing of Deum after anastomoses over clamps by the Martaloff Burget technique. They used silk for both layers, and their results in the main confirm those of Mall and Sabin. Their intarred flanges flattened out much more quickly however i.e. in 14 days, and the mucosa became entirely healed before 6 days had passed.<sup>1</sup>

Gerbode employed the Martaloff Burget technique for gastroenterostomies in dogs, using 2 layers of interrupted silk in some instances and an inner layer of running catgut and external Lembert stitches of silk in others. He observed that the tissue which had been crushed in the clamps usually dropped off in 48 hours so that a granulating bed was left, which in turn was regularly overgrown by mucous membrane at 14 to 17 days. The line of apposition showed pus cells only around the sutures, and this area had regularly healed at 11 days by proliferative fibrosis. The size of the flange began to decrease at 14 days and remained at 28 days only as an area of slight thickening.

One may conclude from these reports that healing after the closed method of anastomosis is at least as rapid as it is after the open method.

Varco Hay and Stevens, of this clinic broadened the field of intestinal surgery immensely when they discovered the improvement in healing of intestinal wounds which results from the local implantation of sulfanilamide. It is their impression that application of the drug inhibits fibrinolysis by the

<sup>1</sup>Of course, these figures that 100 per cent of these anastomoses made in this fashion healed finally when they used catgut for the internal suture, the leakage rate was 100 per cent, and when they omitted the internal running suture altogether, the catgut leaked. In the oblique, mesic, and to-end anastomoses described in this paper there have been no instances of leakage when performed on normal bowel in any of the instances. This certainly is due at least in part to the presence of peritonitis on at least one of the sutured surfaces at all points around the line of apposition. The majority of these anastomoses were performed with end-to-end anastomosis implantation.



Fig 12



Fig 13



Fig 14

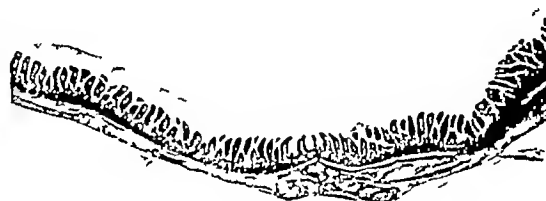


Fig 15

Figs 12 to 15 Photomicrographs showing appearance of line of apposition of anastomosis made in the relief of 5 to 7 days' obstruction in the dog  $\times 6$  Sulfanilamide implanted

Fig 12 Appearance at 1 day The area crushed by the clamps has not yet sloughed There is firm serosal sealing, and both the cotton and the catgut sutures are visible Under high power magnification, very few polymorphonuclear leucocytes are visible around either serosa or in the line of apposition, except in those areas where the tissue had been crushed

Fig 13 Appearance at 6 days Healing is secure, and there is little evidence of inflammation A granulating bed has formed at the luminal end of the line of apposition, and the mucosa is spreading over this area

Fig 14 Appearance at 18 days The granulating bed is almost covered with a thin layer of epithelium The catgut is still present The defect at the base of the ridge of inversion contains a few wisps of cotton suture material

Fig 15 Appearance at 165 days The line of suture is recognized only by the presence of a cotton stitch The inversion ridge has all but disappeared in this specimen

bacteria from the intestinal lumen, and thus promotes primary union

*Procedure in microscopic and gross examination of specimens* Specimens were removed from almost all animals for sections of the suture line at varying intervals after anastomosis They were removed, in the majority of instances, while the animals were still alive (the bowel being reanastomosed for control sections) or immediately after sacrificing by an overwhelming dose of sodium pentobarbital or ether given intravenously Removed

specimens were fixed in 4 per cent formaldehyde solution, and paraffin sections were cut at right angles to the suture line midway between mesenteric and antimesenteric borders All sections were 6 micra thick and were stained with hematoxylin and eosin

*Microscopic findings after obstruction* Gross changes in the bowel resulting from obstruction have already been described Microscopic examination of this distended bowel regularly reveals the following changes edema of all layers, congestion, hemorrhage into the



Fig. 6 a, left, An anastomosis in dog 35 days after performance in the relief of obstruction without sulfanilamide inside. The ridge of inversion is permanent, the usual result

tissues in some spots and polymorphonuclear leucocytic infiltration also of many areas. Despite these changes, 1 of the 8 day obstruction specimens was found to have the mucosa completely healed over the tissue inverted at the time of obstruction.

*Healing after oblique aseptic end-to-end anastomosis with sulfanilamide implantation.* One day after anastomosis the area crushed by the clamps has not yet sloughed (Fig. 12). There is firm sealing of the apposed serosal surfaces, and both the catgut and a cotton suture can be seen. Under higher power the line of inversion between the catgut and the necrotic crush shows some polymorphonuclear leucocytic infiltration, and a few also may be seen about both sutures. There is no evidence of mucosal regeneration.

Six days after anastomosis healing of the apposed serosal surfaces appears very secure (Fig. 13) and there is no low power evidence of inflammation. A granulating bed has formed at the luminal margin of the line of apposition, as Gerbode described, and a few leucocytes can be found here under higher power magnification. The mucosa is rapidly covering this area. The catgut and the cotton suture can be seen neither surrounded by leucocytes.

Eighteen days after anastomosis a single layer of epithelial cells has almost covered the granulating bed at the luminal end of the line of apposition (Fig. 14). A few leucocytes are present in the mucosal edges, but not else



the cholecystectomy lines. b, A similar specimen 5 days after anastomosis. The scar is the absence of sulfanilamide is usually heavier than with the drug.

where. The catgut stitch is still present. The defect at the base of the ridge of inversion results from penetration of the mucosa by a cotton stitch.

At 48 days healing appears complete the catgut has disappeared, and the region of the anastomosis has become difficult to find. The situation remains essentially unchanged at 165 days (Fig. 15) when the point of anastomosis can be identified only by the finding of a cotton suture beneath the serosa. In this specimen the inverted tissue is no longer apparent, and unfolding appears to have occurred as described by Mall.

Unfolding of the inverted flange happened occasionally in the dog experiments and usually had occurred in the late human specimens obtained, but the more common end result in the laboratory is illustrated in Figure 16a, a 235 day old anastomosis. There is complete healing of all the layers, but a 4 millimeter ridge remains. It was regularly found that the diameter of the gut above and below the point of anastomosis became identical within 2 weeks. In 1 instance this had occurred in 6 days.

*Healing after oblique aseptic end-to-end anastomosis without sulfanilamide implantation.* In the absence of sulfanilamide healing progressed at the same rate as with it but throughout the process there was much greater evidence of inflammatory reaction. This reaction has been interpreted as the result of greater bacterial growth. At one day

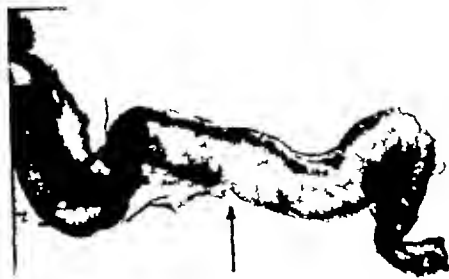


Fig 17a



Fig 17b

Fig 17 An anastomosis from a clinical case, made in the presence of obstruction 1 year before, with implantation of sulfanilamide. a, Gross appearance. The arrow indicates the point of anastomosis. b, Section through the line of apposition.  $\times 6$ . The ridge has not unfolded. A piece of the silk suture is present in the defect in the ridge—it extends over to the mucosal surface. c, Under higher power, polymorphonuclear leucocytes are seen still to be present in contact with silk suture.  $\times 215$ .

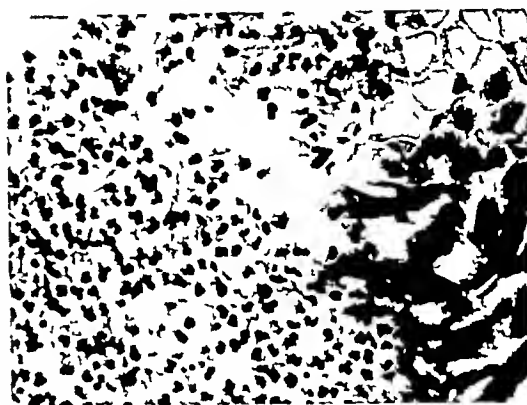


Fig 17c

there is heavy leucocytic infiltration about both the sutures and also in the line of apposition. It is still present at 6 days, but no frank liquefaction is recognized. The ultimate healing is as satisfactory as with sulfanilamide implantation, but there appears to be a heavier scar left (Fig 16b).

*Healing after open anastomosis.* After open anastomosis, only 3 specimens are available. In these few, the most striking finding is a heavy infiltration of leucocytes around each suture and also in the line of apposition. The inverted cuff of tissue is greater than in the closed method, and apposition is far looser and results in a heavier scar than is the case in the closed procedure. It was apparently loose apposition which resulted in leakage in 1 of the dogs.

*Healing after oblique, aseptic, end-to-end anastomosis in the absence of obstruction.* The

mucosal repair reported above is far slower than that reported by Martzloff and his associates. With the thought in mind that obstruction might be responsible, studies were made on 11 anastomoses made in the absence of obstruction, some with and some without sulfanilamide implantation.

Healing progressed in these anastomotic sites in a fashion apparently strictly parallel to that seen after obstruction. At 7 days, when Martzloff found healed mucosa, the mucous membrane covers only  $\frac{1}{3}$  of the granulating surface. In search of some other factor, postoperative and preoperative feeding were considered. When the dogs were allowed only water and milk by mouth, it was found that at 5 days the epithelium had proliferated to the edge of the crush, which had not yet sloughed. At 11 days, healing of the mucosa is complete, and at 15 days, it was found



that glands have formed across the line of anastomosis.

*Healing in clinical cases after aseptic anastomosis.* A few clinical specimens have become available at varying intervals after anastomosis. In the duodenocolic anastomosis of Case 7 the specimen became available at autopsy 9 days after operation. There was still a wide granulating area at the line of apposition internally and a small abscess was found between mattress sutures anteriorly as already mentioned. In Case 12 the patient had had peritonitis for nearly 3 weeks at the time of death, and there was very little healing evident the wound edges pulled apart with minimal tension.

Two anastomoses, performed in the presence of obstruction but without strangulation were obtained from the same patient due to successive operations, the patient ultimately dying of peritonitis from contamination incident to a catheter enterostomy. The first was 9 days old. It shows the area of crush not yet sloughed. There are no leucocytes to be seen. The other was 24 days old at the time of death. Healing is excellent and no leucocytes are visible the mucosa almost covers the granulating area.

The specimen obtained from Patient No. 5 1 year after anastomosis, shows intact healing. Grossly the suture line is difficult to find (Fig. 17). Section shows a silk stitch with polymorphonuclears about it which is presumably being extruded into the lumen, an indication of too deep a bite. In spite of this the amount of contraction of the suture line in a full year is too little to be demonstrable by measurement as already mentioned.

Another year old specimen was obtained from Patient No. 7 at her second operation. The anastomosis had been performed by the Martzloff Burget technique. The site of anastomosis was recognizable grossly by the presence of sutures beneath the serosa, and microscopically only by the abrupt change of mucosal pattern from high jejunal to lower ileac.

*Healing of experimental anastomoses made at the time of obstruction.* In 3 dogs an oblique aseptic, end-to-end anastomosis was performed 15 centimeters above the point of

obstruction, which was made at the same sitting.

In the first 2 sulfanilamide was not implanted and the 3 rows of sutures were placed as closely as possible. Death occurred from perforation one in 3 days and the other at 5 days. The 3 day specimen was autolyzed. In the other perforation had occurred beside a perforating cotton suture on the anterior suture line midway between the angles. Microscopic examination shows a perforation through the ileac wall where a wisp of remaining cotton is visible. There is also a great sheet of polymorphonuclear leucocytes between the apposed surfaces extending to the mucosa near the first perforation. A larger piece of suture is visible in this exudate.

In the third dog sulfanilamide was implanted at least 2 millimeters was allowed between the two rows of sutures, and the animal was milked. The anastomosis healed despite distention and fecal vomiting. The dog died 19 days after operation, living much longer than control dogs subjected to obstruction alone.

#### OBSERVATIONS

The clinical results and the survival rates in the animal experiments leave little doubt concerning the relative safety of the anastomotic procedure described or the advisability of primary anastomosis in preference to other procedures. The technique is adequate in the presence of obstruction and marked degrees of distention is patently very safe for use in elective operations. In Case 7 there may have been some postoperative extension of thrombosis but in no other instance was this observed. It seems justifiable to conclude that this fear entertained by many is not well founded.

Some discussion of the reasons for certain of the steps is in order. Early anastomoses were performed by the Martzloff Burget technique. In many dogs the bowel is sufficiently small so that the anastomosis cannot readily be made secure without inversion of enough tissue to cause necrosis or obstruction. It was for this reason that rotation of the ends with greater obliquity of placement of the clamps was first adopted.

The device described of placing the clamp on the bowel of small diameter is fully as effective when both segments are of narrow lumen, and has been in regular use for end-to-end primary ileotransverse colostomies, the standard procedure in resections of the right colon for cancer at the University Hospitals

In the Martzloff-Burget anastomosis the internal running stitch is silk. In practice, this was found to offer too much friction, thus interfering with easy and clean inversion during removal of the clamps. Fine catgut serves admirably for this purpose, and application with an atraumatic needle minimizes tissue trauma during insertion.

Martzloff, Moore, and Gardner tried what they call the Scarff technique, namely placement of Halsted mattress sutures adjacent to the clamps without an internal running suture, but they found it impracticable because the stitches cannot be placed at right angles to the clamp and close to it with accuracy and therefore without frequently perforating the mucosa. For the reason that this procedure appeared, except for this difficulty, an ideal procedure, it seemed wisest to use the finest size of catgut that would suffice for the mechanics of the operation. The aim, therefore, is to apply the fine catgut only to hold the intestine during the placement of the important Halsted mattress stitches, and for the few minutes to an hour which are needed for serosal sealing to take place between the 2 rows of sutures.

Inasmuch as the removal of catgut is an exudative and liquefying as well as an absorptive process, it is likely to become infected in the course of healing, especially in this position. This is a further reason for the insertion of a minimum of foreign material by use of a very fine strand. It also is responsible for the impression that an expanse of serosa perhaps 2 millimeters wide should be left between the 2 layers of sutures, for healing would be less kindly if infection of the silk sutures were to occur. With observance of this principle, an anastomosis, made at the time of obstruction a few centimeters below it, healed despite distention, vomiting, and finally death from obstruction. The question needs more study.

The evidence presented in this paper indi-

cates that unfolding of the inverted flange cannot be counted on to enlarge the stoma, at least not within months. One must therefore invert enough tissue so as to assure a band of serosal approximation between suture lines, but not enough to interfere to any extent with the lumen. The obliquity of the suture line in the present technique minimizes the danger of obstruction from this source.

The data presented in this paper also are in line with the conclusions of Halsted and Mall that too deep placement of sutures is dangerous. Of the 4 perforations observed following the use of this anastomosis in the presence of obstruction (3 dogs and 1 patient), 1 at least occurred around a cotton suture that had pierced the mucosa. The placement of stitches which catch the bulk of the muscle but no submucosa would seem a less hazardous error only if they are tied loosely enough not to tear the tissues at the time.

With regard to the rate of healing in the presence of obstruction, the data presented indicate that the deeper layers heal fully as fast and securely as by other methods or in the absence of obstruction. With regard to the mucosa there is some question. The experimental animals were fed following obstruction in order to simulate the situation found in clinical cases, and they therefore had food and other matter in the intestine at the time of anastomosis. In any case, the mucosa healed in anastomoses after obstruction as rapidly as in unobstructed bowel in which the dogs were fed. The faster rate of mucosal healing, which has been reported by Sabin and Martzloff, could be approximated by starvation of the animals.

#### CONCLUSIONS

1. An oblique, aseptic, end-to-end anastomosis designed for use on intestine in the presence of obstruction is described.

2. A series of 16 resections for strangulating obstructions in clinical cases resulted in 2 deaths and 14 recoveries.

3. Laboratory study of this anastomosis indicates that it is highly reliable, either in the presence or absence of obstruction.

4. Healing in bowel that has been obstructed 5 to 7 days and then anastomosed by this

technique is apparently as rapid and secure as in the absence of obstruction.

5 Late contraction along the suture line apparently does not occur

#### REFERENCES

1. DICKIN, C. *Surgery* 939, 3 342.
2. DICKIN, C., and BROWN, S. P. *Surgery* 943, 3 94.
3. GERRARD, F. *Surg. Gyn. Obst.*, 942, 74, 403.
4. HALSTED, W. S. *Am. J. M. Sc.*, 337 94, 456.
5. HORMAN, E. *Johns Hopkins Hosp. Bull.*, 1920, 3 300.
6. MCKITTERICK, L. S. \ *England J. M.*, 941, 3 647.
7. MALL, F. *Johns Hopkins Hosp. Rep.*, 896, 76.
8. MARTELOFF, K. H., and BORDET, G. E. *Arch. Surg.* 93, 3 36.
9. MARTELOFF, K. H., MOORE, P. H. and GARDNER, J. *West. J. Surg.* 939, 47 6 1.
10. OGDON, J. C., and SMITH, I. H. *Ann. Surg.* 1931, 95 240.
- PARSONS, E. M., and KERR, H. H. *Johns Hopkins Hosp. Bull.* 908, 9 32.
- SABIN, F. R. *Johns Hopkins Hosp. Bull.*, 920, 31 259.
3. VANCE, R. L., H. Y. L. J. and STEVENS, B. *Surgery* 941 9 863-870.
4. WUNDERSTEIN, O. H. *Surg. Gyn. Obst.*, 941 73 675-692.
5. WUNDERSTEIN, O. H., REA, C. E., SMITH, B. A. and SCHWYTER, H. C. *Surg. Gyn. Obst.* 1930, 62 85.

# WOUND HEALING—EXPERIMENTAL AND STATISTICAL STUDY

## III Experimental Observations

S ARTHUR LOCALIO, M D, WALTER CASALE, M D, and  
J WILLIAM HINTON, M D, F A C S, New York, New York

**T**HE present study was undertaken in order to compare the effects of the most commonly used sutures on wound healing. The technique used by one operator was employed throughout the experiment. Fine suture materials of comparable size and tensile strength were used.

Several methods of quantitatively estimating wound healing have been devised. Carrel and Hartman in 1916 described a method of measuring the rate of cicatrization of skin defects. The size of the wound was traced on cellophane and the area was then determined by means of a planimeter. Measurements were made daily. This method is limited to superficial defects. From these studies, Du Noy (5-8) was able to evolve a series of mathematical equations expressing the laws of cicatrization of surface wounds. Douglas attempted to simplify the planimeter method used by Carrel and Du Noy by employing a gravimetric method for determining the superficial area of wounds. A tracing of the exact pattern of the wound was made and then transferred to bond paper of known weight per square centimeter. The bond paper pattern was then weighed, the weight divided by a constant (the weight of one square centimeter of the paper) and the exact area in square centimeters determined.

Howes and Harvey (10) and Howes, Sooy, and Harvey (11) employed a thread tester to determine the strength of wounds. This procedure consisted of determining the tensile strength required to pull the wound edges apart. After the wound was excised, it was placed in a standard thread testing machine,

From the Departments of Surgery and Pathology of the New York Post Graduate Medical School of Columbia University. This work has been made possible by grants from Mrs. G. Macculloch Miller, Mr. Stewart Hopps and the Surgical Fund of the New York Post Graduate Medical School. Parts I and II are to appear in later issues of the *International Abstract of Surgery*.

and its tensile strength was determined. Whipple has used a similar method, and Preston has recently used a simplified modification of this method.

In his studies of fibroplasia and wound healing, Harvey determined the tensile strength of a wound by disruption with air pressure. The rat stomach was used for most of these studies. The organ was removed, the esophagus was tied, and a cannula was inserted into the duodenum. Air was admitted at a uniform rate through the cannula, until disruption of the wound or the stomach occurred. The pressure was measured by a mercury manometer recording on a revolving drum. This method is restricted to studies of healing wounds in hollow viscera.

Lanman and Ingalls modified this method. They used a mercury sphygmomanometer, the closed circuit of which was connected to a free length of rubber tubing to which a lumbar puncture needle was attached. The needle was inserted into the peritoneal cavity or into a hollow viscus, and the air pressure was increased until disruption occurred.

Burr, Harvey, and Taffel (1) and Burr, Taffel, and Harvey (2) have recently described an electrometric method of measuring the healing of wounds. This procedure is based on the fact that rapidly dividing masses of cells generate an electric potential which can be measured.

In our studies we used the method of Lanman and Ingalls, with a slight modification. A detailed description of our method follows.

### METHOD

Shaving of the abdomen of each rat was done 24 hours prior to operation so that incidental cuts might have time to heal. Instruments, towels, and gloves were sterilized. The room used for these experiments contained

many other animals and the air was probably highly contaminated. Ether narcosis was employed and maintained. The abdomen was prepared with a mercurial antiseptic, and the field was draped with a sterile towel. An incision exactly 3 centimeters in length was made just to the right of the midline and half way between the xiphoid and the base of the penis. The abdomen was opened with a sharp scalpel so that traumatization of tissues was minimal. Bleeding was slight and bleeding points were easily controlled with light pressure. The use of ligatures to obtain a dry field was not found necessary. The peritoneal cavity was not explored and the abdominal viscera were not molested.

Six equally spaced sutures of the material to be tested were placed in the peritoneum and in the fascia. Because of the delicacy of these structures it was necessary to take a small bite of rectus muscle with each of the sutures. Fine full circle half inch, French eye cutting edge needles were used in order to reduce forceps manipulation to a minimum. Interrupted sutures of No. 0000 chromic and plain catgut of a standard brand Deknatel serum proofed B silk, Deknatel B nylon Filings No 36 alloy steel wire and Gudebrod's No. 000 cotton were used. Catgut sutures were tied with triple throw knots with all the throws square and the sutures were cut about 3 millimeters from the knot. Silk, cotton, and wire were tied with true square knots and the sutures cut about 1 millimeter from the knot. It was found that nylon sutures slipped unless tied with four knots with all throws square and occasionally even these sutures were found untied. Therefore these sutures were tied with a quadruple knot and cut 1 millimeter from the knot. Strangulation of tissues was carefully avoided. The edges of the sutured wounds were approximated as closely as possible. The skin was not utilized in the experiment and was therefore closed with a continuous suture.

The skin was saturated with ether and the wound while still wet, was covered with a piece of clean unsterilized adhesive tape to prevent the animals from removing the skin sutures. The adhesive tape usually remained in place until the 3d or 4th postoperative day, by which time sufficient healing had occurred

to prevent exposure of the underlying fascia.

Animals were sacrificed daily until the 9th day and thereafter on the 13th, 21st, 31st, 45th, and 62nd days. Chloroform was used for this purpose. Immediately after the death of the animal the wound area was painted with a mercurial antiseptic. Skin sutures were removed with sterile instruments, the skin wound was opened and cultures were taken. The swab was first passed on a blood agar plate and then placed in beef broth.

The skin was not tested since it is of secondary importance in the healing of abdominal wounds. It was dissected free at the level of the superficial fascia until the entire wound and both lower abdominal quadrants were exposed. Pressure studies were then made.

A sharp, No. 24 hypodermic needle was inserted into the peritoneal cavity through the left lower quadrant. It was connected to a short rubber tube which in turn was connected to the air bulb of a sphygmomanometer. Air was slowly pumped into the peritoneal cavity until the abdominal wall was raised from the peritoneal viscera. This procedure was necessary so that loops of intestine would not adhere to a second needle inserted to measure the intraperitoneal pressure. A second No. 24 hypodermic needle was then inserted into the peritoneal cavity through the right lower quadrant. This needle was connected by means of rubber tubing to a mercury containing U tube calibrated in millimeters. The intraperitoneal pressure was increased slowly 2 millimeters at a time, until disruption occurred, either of the wound, the pelvic peritoneum, the iliac vessels or the scrotum. Most wounds which disrupted did so suddenly and over most of their extent. Occasionally a few bubbles of air were seen coming from the wound and partial or complete disruption occurred shortly thereafter. Following the leakage of air it was difficult to raise the mercury column more than 2 to 3 millimeters. By proceeding slowly and noting the level at which the mercury column no longer rose, a fairly accurate reading could be obtained. In some of the animals disruption occurred not in the wound but in one of the previously indicated areas the most frequent being the pelvic peritoneum which disrupted suddenly and dis-

TABLE I—EXPERIMENTAL MATERIAL

Days after operation	Number of animals available for study						Total animals
	Suture material						
	Catgut		Silk	Wire	Cotton	Nylon	
	Plain	Chronic					
1	3	3	5	5	5	5	26
2	3	3	5	5	5	5	26
3	3	3	6	5	5	5	27
4	4	3	5	5	5	5	27
5	3	3	5	5	5	5	26
6	3	3	5	5	5	5	26
7	3	3	5	5	5	5	26
8	3	3	5	5	5	5	26
9	3	3	5	5	5	5	26
13	2	1	2	2	2	2	11
21	1	1	2	2	2	2	10
31	1	1	2	2	2	2	10
45	2		2	2	2	2	10
62	1	1	2	2	3	2	11
Totals	35	31	56	55	56	55	288

charged air into the tissues of the thigh. Occasionally, air was discharged into the thigh suddenly or slowly through rents in the pelvic peritoneum about the exit of the femoral vessels, and once into the scrotum.

After pressure readings were completed the entire wound was excised and placed in formalin for histological study.

Fine hypodermic needles were used since it was observed that large caliber needles frequently caused subcutaneous emphysema due to leakage of air about the needle. Animals in which subcutaneous emphysema developed, and those in which air leaked about the needle before disruption occurred, were discarded. In rare instances bits of muscle plugged the needle, and pressure readings could not be obtained.

Although this method, like that of Harvey and that of Lanman and Ingalls, does not give the absolute strength of the wounds, relative values of the strength of wounds could be obtained which were adequate for purposes of comparison.

Bacteriological study of wounds was restricted to the determination of aerobic organisms only.

TABLE II—PRESSURE NECESSARY TO CAUSE DISRUPTION OF ABDOMENS OF UNOPERATED ANIMALS (CONTROLS)

No of animal	Pressure in mm. of mercury	No of animal	Pressure in mm. of mercury
1	93	11	93
2	98	12	108
3	93	13	95
4	87	14	96
5	101	15	115
6	87	16	95
7	93	17	90
8	96	18	104
9	93	19	108
10	98	20	111

Total animals 20 mean tensile strength 97.7 millimeters standard error of the mean 1.75 millimeters

Hematoxylin and eosin sections of all wounds were studied. These sections did not include the skin of the abdominal wall.

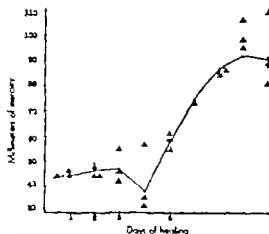
#### MATERIAL

Young, white adult male rats, bred from stock purchased from a commercial breeder, were utilized in the experiment. Data on 288 operated upon animals (Table I, IV-A, V-A, VI-A, VII-A, and VIII-A)<sup>1</sup> are reported. A group of 20 rats was used as a control.

Disruption occurred in the peritoneum of the 20 control animals, at an average pressure of 98 millimeters plus or minus 5.2 millimeters of mercury (Table II). The range of observations in this control group was from 87 to 115 millimeters of mercury. The standard error of the mean was 1.75 millimeters.

From the value of the mean tensile strength, and the value of the standard error of the mean, we may draw some conclusions as to the probable "true" value of the mean tensile strength of the abdomens of healthy rats. Since 99.7 per cent of the sample means vary from the population mean by not more than plus or minus three times the standard error of the mean, we may conclude that the true mean tensile strength, that is, the mean tensile strength of the abdomens of all rats similar to the ones used in this study, is almost surely not less than 92.8 millimeters nor more than

<sup>1</sup>Tables IV A, V A, VI A, VII A and VIII A will appear in Part IV in the October issue.



Graph Scatter diagram of tensile strength of catgut sutured wounds. Dots indicate plain catgut, dot in triangle, chromic catgut.

103.2 millimeters. The fiducial probability or degree of reasonable expectation, is 997 out of 1,000 that the true mean lies between 92.8 and 103.2 millimeters.

#### TENSILE STRENGTH OF SUTURED WOUNDS

**Catgut.** The data relative to the strength of catgut sutured wounds are presented in Table IV A and charted in Graph 1. There was little difference in mean tensile strength from day to day between wounds sutured with plain and those sutured with chromic catgut (Table III).

Croston, F. E. and Corbett, D. J. *Applied General Statistics*, 14. New York: Prentice Hall, Inc. 1939.

TABLE IV.—DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH CATGUT DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure, mm. mercury necessary for disruption				Value of "t" at .05 level	Remarks
Days after operation					
44	47			19	N.S.G.
	47	47		99	N.S.L.
		47	34	99	N.S.L.
			34 73	1	

N.S.G. Not significantly greater  
N.S.L. Not significantly less  
S.G. Significantly greater

TABLE III.—COMPARATIVE TENSILE STRENGTH OF PLAIN AND CHROMIC CATGUT SUTURED WOUNDS

Days after operation	Mean pressure, in mm. of mercury necessary to disrupt wounds		Number of wounds treated		Degrees of freedom	Value of "t" at .05 probability level	Remarks
	Plain catgut	Chromic catgut	Plain catgut	Chromic catgut			
	44		3	3		66	N.S.
	46					27	S.
		47				66	N.S.
		47				99	N.S.
3	35	35	3	3			N.D.
4	35	35	3	3	4		N.D.

\*For an explanation of the application of Fisher's "t" test, see *Applied General Statistics*, by Croston & Corbett, pp. 7-23.

†No difference.

The data presented in this table apply only in those instances in which disruption occurred in the wound because we have no measure of tensile strength of wounds in those instances in which disruption occurred in other sites. When disruption does not occur in the wound the tensile strength is at least as great and possibly greater than that of the pelvic peritoneum.

As shown in Table III from the 1st through the 4th day no significant differences<sup>1</sup> in mean

When we compare means made that there is no significant difference—either significant increase or significant decrease—the mean is not statistically significant, as indicated by the fact that the value of the difference between the two means is positive (taking by subtracting the second from the first, in "impaired" cases) is less than the value of the difference between the two means, greater than the value of the ratio at the selected critical probability level, which in these cases, taken to be .05 level of significance.

TABLE V.—DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH SILK DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure, mm. mercury necessary for disruption				Value of "t" at .05 level	Remarks
Days after operation					
77	95			99	S.G.
	95	95		99	L.
		95		99	S.

S.G. Significantly greater  
L. Significantly less

TABLE VI — DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH COTTON, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure mm mercury, necessary for disruption					t	n	Value of $t'$ at or level	Remarks
Days after operation								
1	2	3	4	5				
64	74				3 68	8	3 36	SG
	74	60			7 22	8	3 36	SL
		60	71		3 26	8	3 36	NSG
			71	86 5	4 01	~	3 50	SG

SG Significantly greater  
 SL Significantly less  
 NSG Not significantly greater

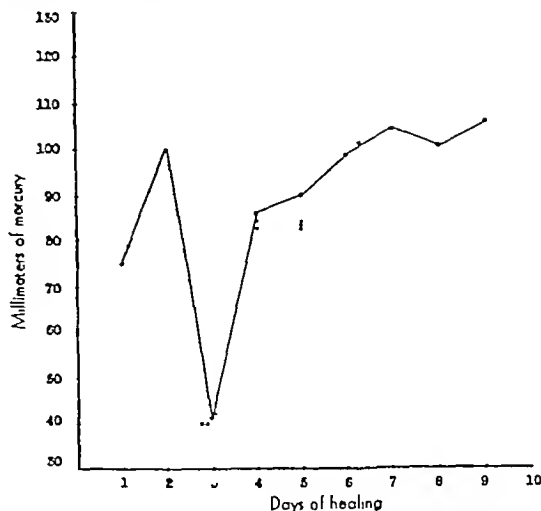
tensile strength were observed between wounds sutured with plain and those sutured with chromic catgut. On the 5th and 6th days no experimental difference was observed in the means. On the 7th day there was not sufficient material for a test because only one of three wounds sutured with chromic catgut disrupted.

From these results it may be seen that so far as mean tensile strength is concerned there is no difference between the effect of chromic and the effect of plain catgut. Statistically speaking, we have cast no doubt upon an hypothesis that the true difference between the mean tensile strength of wounds sutured with chromic catgut and of those sutured with plain catgut is zero. Therefore, when comparing the results of the use of catgut with the results of

TABLE VII — DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH WIRE, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure mm mercury necessary for disruption					t	n	Value of $t'$ at or level	Remarks
Days after operation								
1	2	3	4	5				
65	64				3	8	3.36	NSL
	64	52			3.74	8	3.36	SL
		52	75		12.1	8	3.36	SG

NSL Not significantly less  
 SL Significantly less  
 SG Significantly greater



Graph 2 Scatter diagram of tensile strength of silk sutured wounds

the use of the nonabsorbable sutures, we shall not differentiate between catguts, but shall combine them into one catgut group.

A lag period of 4 days was observed. This period, with reference to tensile strength of healing wounds, is that period just preceding the initiation of a continued and uninterrupted increase in tensile strength.

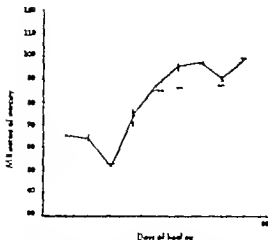
Increase in tensile strength of catgut sutured wounds did not occur until the 5th day (Table IV). There was a slight increase in mean tensile strength by the second day, and then a decrease during the remaining 2 days of the lag period. However, the tensile strengths on these days were not significantly greater or less than on the day immediately preceding. The increase immediately after the end of the

TABLE VIII — DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH NYLON, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

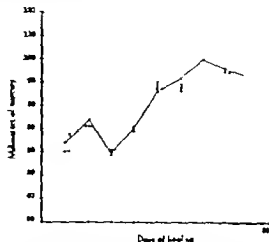
Mean pressure mm mercury necessary for disruption					t	n	Value of 't' at 0.1 level	Remarks
Days after operation								
1	2	3	4	5				
65	58				1 00	8	3 36	NSL
	58	70			3 75	8	3 36	SG

NSL Not significantly less  
 SG Significantly greater





Graph 3. Scatter diagram of tensile strength of bra sutured wounds.



Graph 4. Scatter diagram of tensile strength of cotton sutured wounds.

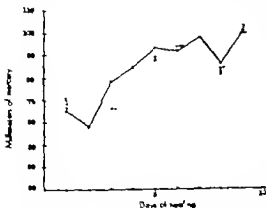
lag period that is, from the 4th to the 5th day was significant. On the 4th postoperative day the wounds were actually weaker than during the first 3 days. A similar phenomenon was observed at some time during healing in all wounds irrespective of the type of suture material used. Beginning with the 5th day the mean pressure necessary to cause disruption increased rapidly. On the 7th day 3 of 6 wounds disrupted. On the 8th day there were no wound disruptions. On the 9th day only 1 of 6 wounds disrupted and thereafter disruption no longer occurred in the wounds.

**Silk.** The data relative to tensile strength of wounds sutured with silk are summarized

in Tables V and V A and charted in Graph 2. The lag period in silk sutured wounds persisted for 3 days and actual increase in tensile strength began on the 4th day (Table V). There was an increase in mean tensile strength by the 2d day and a decrease from the 2d to the 3d day. In each instance the variation from one day to the next was significant. Likewise the increase immediately following the lag period was significant. In the case of silk sutured wounds the lag period was one day shorter than in the case of catgut sutured wounds, 3 days as against 4 and in addition the increases and decreases in tensile strength of silk sutured wounds during this period were significant whereas they were not significant in the case of catgut.

Following the lag period the tensile strength of the silk sutured wounds increased very rapidly and beginning with the 6th day disruption no longer occurred in the wound. On the 4th day 4 of 5 wounds disrupted and on the 5th day 1 of 5 wounds disrupted.

**Cotton.** The data relative to the tensile strength of cotton sutured wounds are summarized in Tables VI and VI A and shown graphically in Graph 4. There was a significant increase in mean tensile strength of the wound from the 1st to the 2d day and a significant decrease from the 2d to the 3d day. From the 3d to the 4th day there was an increase in mean tensile strength which was not



Graph 5. Scatter diagram of tensile strength of nylon sutured wounds.

significant and from the 4th to the 5th day an increase which was significant (Table VI)

The picture presented here is different from that shown in catgut and silk sutured wounds. In these 2 instances, there was first, an increase in mean tensile strength then a decrease, then a significant increase. This last increase occurred directly following the lag period. In fact, this increase may be associated with the beginning of the post-lag period. It was always significant. However, in the case of cotton, the increase directly following what, in the case of the two suture materials previously described, would have been the end of the lag period, was not significant. The increase does not become significant until we pass from the 4th to the 5th day. The question arises as to the interpretation of this phenomenon. Is the lag period in the case of cotton 3 days long or 4 days long? It would seem from the statistical results that the lag period is 4 days in length and not 3 days, for the reason that the increase from the 3d to the 4th day is not significant.

The tensile strength of the wound increased rapidly beginning with the 4th day, and by the 6th day disruption no longer occurred in the wound. On the 5th day, 3 of 5 wounds disrupted.

**Wire** There was a lag period of 3 days in wound sutured with alloy steel wire, with a drop in tensile strength observed on the 2d and 3d days. Table VII presents the results of an analysis of the increases and decreases in mean tensile strength during and directly following the lag period. The decrease observed from the 1st to the 2d day was not significant but the increase from the 2d to the 3d day was significant. The increase in strength directly following the lag period, that is, from the 3d to the 4th day, was significant.

Following the lag period the tensile strength increased rapidly and beginning with the 6th

day, disruption no longer occurred in the wound. Data regarding these observations are summarized in Table VII-A and charted in Graph 3.

**Nylon** The data relative to the tensile strength of nylon sutured wounds are summarized in Tables VIII and VIII-A and illustrated in Graph 5.

The observed lag period in wounds sutured with nylon persisted for 2 days (Table VIII).

The lag period in nylon sutured wounds was the shortest of all, and was similar to that of wire sutured wounds in that there was no increase, significant or otherwise, preceding the decrease which in every case marked the last day of the lag period. There is just one qualification to this statement. In the case of cotton, the statistical evidence so far uncovered has not been sufficient to set definitely the end of the lag period, and therefore we cannot include cotton in our remarks.

Tensile strength in nylon sutured wounds increased rapidly beginning with the 3d day. On the 5th and 6th days only 1 of 5 wounds disrupted. Thereafter disruption occurred only in the pelvis.

#### REFERENCES

- 1 BURR, H S, HARVEY, S C, and TAFFEL, M. *Yale J Biol*, 1938, 11 103
- 2 BURR, H S, TAFFEL, M, and HARVEY, S C. *Yale J Biol*, 1940, 12 483
- 3 CARREL, A, and HARTMAN, A. *J Exp M*, 1916, 24 429
- 4 DOUGLAS, B. *Ann Surg*, 1921, 73 673
- 5 DU NOUY, P L. *J Exp M*, 1916, 24 451
- 6 *Ibid*, 1919, 29 329
- 7 *Ibid*, 1917, 25 721
- 8 *Ibid*, 1916, 24 461
- 9 HARVEY, S C. *Arch Surg* (Cushing Birthday Volume), 1929, 1227
- 10 HOWES, E L, and HARVEY, S C. *N England J M*, 1929, 200 1285
- 11 HOWES, E L, SOOY, J W, and HARVEY, S C. *J Am M Ass*, 1929, 92 42
- 12 LANMAN, L H, and INGALLS, T H. *Ann Surg*, 1937, 105 616
- 13 PRESTON, D J. *Am J Surg*, 1940, 49 56
- 14 WHIPPLE, A O. *Ann Surg*, 1933, 98 662

# ACUTE OBSTRUCTIVE CHOLECYSTITIS AND THE APPLICATION OF THE PRINCIPLES OF ITS RATIONAL TREATMENT

JAMES H SAINT M.D., M.S. F.R.C.S (Eng.) F.A.C.S Santa Barbara, California

IN any case of acute obstructive cholecystitis operation will be necessary sooner or later if the ultimate cure of the patient is to be achieved. Consequently the question of importance which arises in every case of this disease is that of the time when it should be performed and, in particular whether it should be undertaken as an emergency measure during the attack. Although it is true that the majority of patients will recover spontaneously from their acute attack and therefore can be dealt with by elective surgery at a later date the knowledge that this is so can prove a dangerous possession there is little doubt that a more than occasional case has terminated fatally from a peritonitis caused by perforation of the gall bladder following upon gangrene as a result of this knowledge having given rise in the minds of those responsible for treatment, to the false hope and expectation that conservative measures alone would suffice to bring about the recovery of the patient from his attack. Such deaths give rise to two surmises the first that timely surgical intervention would have averted these catastrophes and the second that at some period during the fatal attack the indications for such intervention must have been present but went unheeded.

The decision of whether operation should be undertaken during an attack will always remain of the "hit or miss" variety until and unless these indications are recognized as such. The ability to recognize them depends essentially upon a knowledge of the pathology and the symptomatology to which it gives rise allowing of an interpretation of the latter in terms of the former. Treatment based upon this knowledge constitutes the only logical or rational treatment and a striking feature of

the literature which cannot but lead one to the conclusion that this form of treatment is not practiced in general is the signal lack of mention of specific indications for operation. This omission in the literature is not only largely responsible for the confusion which has arisen regarding the time when operation should be undertaken but also indicates that the rational treatment has not been understood and therefore not applied.

Because of the fundamental importance of an understanding of the pathology this aspect of acute obstructive cholecystitis will be summarized and briefly described also will be the principles of treatment which follow as the logical sequel of its consideration.

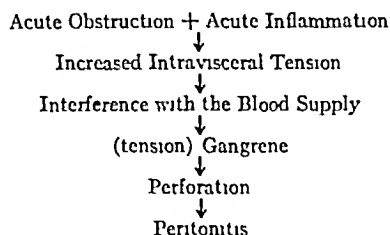
1 Both obstruction of the outlet of the gall bladder and acute inflammation in its wall play a part in establishing the disease but its outcome is largely determined by the obstructive element. While the commonest cause of obstruction is impaction of a stone in the region of the cystic duct, it may also result from the occlusion of this duct by inflammatory edema.

2 The result of this combination occurring in the gall bladder is an increase in its intra-visceral tension (such as will occur in any hollow muscular viscus which happens to become the seat of this combination). This increased tension is brought about through augmentation of the fluid contents of the gall bladder by both exudation and transudation into its lumen the former a result of the inflammatory reaction the latter following congestion of the mucosal and submucosal veins and capillaries consequent upon compression of the blood vessels, passing through the wall, during the forcible contractions of the unstratified muscle these contractions representing Nature's attempt to overcome the obstruction.

From the Division of Surgery, Sutter Clinic.

3 This increased tension may become so acute as to interfere with the blood supply and may do so to such an extent that gangrene of the gall bladder, to be followed later by perforation and extravasation of its contents, will occur. This "tension" gangrene always begins at the spot farthest from the source of blood supply and so, in the case of the gall bladder, first appears at the fundus.

Thus the following represents a synopsis of the simple, but ill understood, pathology of this condition



4 It is obvious from the pathology, as here outlined, that the outcome in any given case depends upon whether or not the increased tension within the gall bladder is relieved. If left to Nature it may be relieved in one of two ways (a) The obstruction is overcome or removed by natural means (e.g. the dislodgment of a stone obstructing the outlet) so allowing the contents to escape *per vias naturales*. In this event the need for surgical intervention does not arise for the patient will recover spontaneously from the attack. In such a case, elective surgery can be undertaken at a later date. (b) By escape of the contents through a rupture of the gall bladder after gangrene has occurred, this catastrophe representing the natural relief of the increased intravisceral tension in the gall bladder in the presence of an obstruction of its outlet which Nature herself is unable to remove or otherwise overcome. It is in the prevention of this dangerous possibility, which materially increases the chances of a fatal outcome, that surgery assumes its important rôle for, once the pathological changes have progressed to the stage when Nature herself is unlikely to relieve the increased intravisceral tension except by extravasation of the contents of the gall bladder through a rupture in its gangrenous wall, the obvious and rational proce-

sure is to relieve it by surgical intervention before this catastrophe has had time to take place. The clinical recognition of this stage is therefore of crucial importance.

5 The most important single clinical manifestation which warrants the assumption that the pathological changes have progressed to this stage, and which therefore indicates that the time has arrived to operate for relief of the increased intravisceral tension if the more serious terminations of the disease are to be prevented, is the development of a tender, palpable mass in the right upper abdominal quadrant. The reason for this lies in the pathological significance of this clinical finding for it tells us that the gall bladder has undergone marked changes, having become grossly enlarged and tensely distended, the result of its increasing fluid contents having been unable to escape through the cystic duct because of the obstruction present in this region and thus giving rise to an increase in the intravisceral tension of dangerous degree. It might be mentioned that, if noted early in its development, this mass will present the typical characteristics of a distended gall bladder as regards shape, definition, dullness on percussion, and relations. Later, with extension of the inflammation to the visceral peritoneum the gall bladder usually becomes buried in omentum and the mass, while retaining the gall-bladder relations, becomes more easily detectable because of the increase in its size but loses the shape and definition of the free gall bladder and at the same time tends to become more fixed. Other important manifestations indicating a progressive pathology (and usual accompaniments of the sign just mentioned) are a continuously increasing pulse rate, a spreading rigidity of the abdominal muscles in the gall-bladder region, and a deterioration of the patient's general condition.

In a recent article (6) the writer dealt in greater detail with these general principles governing the rational treatment of acute obstructive cholecystitis, but it is realized that those who are unfamiliar with them may find that difficulties arise in their attempts to apply them to the individual case. Since their ultimate effectiveness depends essentially upon this application being carried out successfully,

the writer believed it would be of help to present and discuss the following two representative cases of the disease managed in accordance with these principles.

**CASE 1.** Mr J. R., aged 66 seen first about 7:00 p. m. on December 6, 1930. This man had begun to have an attack of typical biliary colic some 4 hours previously and gave a history of several similar attacks during the past few years. He had never been jaundiced. He stated that this attack was the most severe he had ever experienced and that there had been some upper abdominal discomfort for several days before the onset of the acute pain. The patient was in great distress because of the severity of the pain which was causing him to roll about the bed in agony and was accompanied by nausea and vomiting. His pulse and temperature were both normal and examination of the abdomen disclosed a complete absence of any tenderness, rigidity or palpable mass. Sedatives were prescribed in the hope that this attack would pass off as those in the past had done. He was seen the following morning about 8:30 a. m. He had had poor night, having obtained little sleep because of the pain. Colic-like exacerbations had been frequent with accompanying nausea and vomiting the vomitus retaining its character of greenish, bitter fluid. His pulse had increased to 90 beats per minute and his temperature was 98.5 degrees F. Examination of the abdomen now disclosed the presence of definite tenderness over the gall-bladder region accompanied by a involuntary rigidity of the upper part of the right rectus abdominis muscle; there was a questionable mass in the gall-bladder area, but one could not be quite certain of its presence at this time. The provisional diagnosis of early acute obstructive cholecystitis was now made and the patient urged to enter hospital for further observation. After admission to the Santa Barbara Cottage Hospital, morphia was administered for the pain and intravenous therapy begun to replace lost fluids. Urinalysis was negative and the leucocyte count was 16,350 per cubic millimeter of blood, with polymorphonuclear cells accounting for 80 per cent. The patient was seen again about noon. He looked worse than when seen earlier. No jaundice was present. His temperature was now 99.6 degrees F. and his pulse had increased to 110. On examination of the abdomen he was more tender the area of rigidity had increased and now there was no doubt about the presence of a palpable mass in the region of the gall bladder under the rigid musculature. This mass measured some 6 centimeters in diameter moved slightly on respiration was dull on percussion and its lower edge could be well defined. It was advised that operation should be undertaken as soon as arrangements could be made and it was begun about 3:00 p. m., i. e. some 24 hours after the onset of his attack. Through Kocher subcostal incision—that often employed by the writer in his explorations

of the biliary tract—the peritoneal cavity was opened and the omentum was found enveloping the gall bladder. It was readily separated from the gall bladder to reveal that viscous the color of a plum, grossly enlarged and tensely distended. Cholecystectomy was performed without difficulty the operation being followed by uneventful recovery.

The gall bladder was full of dark bilious fluid under great tension and no stones were present. The wall was greatly thickened and edematous, and the mucosal surface varied in color from dark red in the region of the neck to black at the fundus. The cystic duct was stenosed to such a degree that only with difficulty could a fine probe be inserted into it.

Pathological examination of the excised gall bladder confirmed the clinical diagnosis of acute cholecystitis and showed the presence of gangrene of the fundal mucosa.

Several points of interest arise in connection with this case. We were fortunate in seeing this patient so early in his acute attack for this enabled us to observe the progress of the case almost from the onset. Can any significance be attached to the upper abdominal discomfort which was present for several days before the onset of colic? It is suggested that this was due to a mild degree of intramural inflammation resulting in some dysfunction of the gall bladder and in a sufficient degree of edema to cause eventual obstruction of the cystic duct the stenosis of the duct probably due to fibrosis resulting from previous inflammation predisposing to the earlier occurrence of the obstruction. The onset of biliary colic indicated that an acute obstruction to the outlet of the gall bladder had taken place the colic being due to the increased forcible contractions of the unstriated muscle of the gall bladder wall, representing the attempt by Nature to overcome the obstruction. When the patient was first seen and no abnormal physical findings were present the only diagnosis which could be made was biliary colic due to acute obstruction of the outlet of the gall bladder. The question of prognosis, therefore depended upon whether the obstruction would be relieved as it had been on previous occasions, with disappearance of symptoms, or whether it would persist with the possible development of the condition we know as acute obstructive cholecystitis. This question arises in every case of biliary colic—just as the severe colic dominates the clinical picture so obstruction of the outlet of the gall

bladder dominates the pathological one. That the pathology was progressive became evident the next morning when both tenderness and rigidity were found, presumably due to contiguous irritation of the parietal peritoneum by the gall-bladder serosa. These new developments, together with the persistence of the biliary colic, appeared sufficient to justify the provisional diagnosis of early acute obstructive cholecystitis, but the writer was not of the opinion (and never is in similar cases) that there was present at this time any indication for operation as an emergency measure, for at this early stage, the chances of relief of the obstruction, with recovery from the attack, ordinarily exceed those of its persistence, with progression of the pathology. However, clinical manifestations which point to this diagnosis should nevertheless be regarded as signals calling for close observation of the patient.

The presence of a questionable mass at this time pointed to the possibility of distention of the gall bladder and, if this conjecture were correct, to the probability that a definite mass would appear sooner or later as a result of a continued increase in size of the gall bladder and the envelopment of this viscus by the omentum playing its usual protective rôle. This probability became a certainty within a few hours, showing the rapidly progressive nature of the pathological process with which we were dealing, for some 20 hours only had elapsed since the first examination had disclosed an abdomen in which there was no tenderness, rigidity, or palpable mass. This finding indicated at once that the gall bladder had become tensely distended and enlarged much beyond its size at the beginning of the attack (when it was not palpable at all). The only possible explanation for these rapidly progressive changes was that they represented the result of the combination of obstruction and inflammation occurring together in this organ and indicating the presence within the gall bladder of a tension acutely increased to a dangerous degree. The pathological process had therefore progressed to the stage when, according to the rational treatment, it was considered safer to relieve the increased intra-visceral tension by surgical intervention than

to leave its accomplishment to Nature in the hope that she would do this *other than* by gangrene and perforation. Consequently the patient was advised that the time had come when operation should be undertaken as soon as possible. To have decided at this time that conservative treatment should be adopted would have appeared to the writer an indication of lack of understanding and appreciation of the pathological significance of this clinical manifestation.

It was interesting to observe the continuous increase in the pulse rate, a feature which could not have been ignored as indicating the progressive character of the pathological process however much the lack of other clinical manifestations might have tended to mask this progression. As it was and, in the writer's experience, as is usual, other clinical features confirmed the behavior of the pulse as further indications that the patient's condition was steadily becoming worse.

The findings at operation were exactly those which were expected, namely, a grossly enlarged and tensely distended gall bladder, thick walled, plum-blue in color and enveloped by inflamed and matted omentum. Immediately on withdrawal of the trocar from the cannula inserted through the fundus to evacuate the fluid contents and so facilitate the performance of cholecystectomy, dark colored bile gushed forth, showing the great, and quite abnormal, tension under which it had been imprisoned in the gall bladder. Here, then, was a case of such severity that obvious interference with the blood supply occurred within 24 hours—no hollow muscular viscus will become this color except as a result of interference with its circulation, for inflammation alone does not produce this type of change—and yet no stones were present. Such a case as this affords as definite a proof, from the pathological standpoint, of the fallacy of the theory advanced by Denton that interference with the blood supply is due to pressure on the cystic vein and lymphatics by an impacted stone, as did Kreider's work on anatomical grounds. Moreover, *the pathological condition of the gall bladder disclosed at operation provided ample evidence that the clinical manifestations, on the presence of which the decision to operate*

was made had been interpreted correctly as indicating the advisability of immediate operation. The fact that gangrene of the fundal mucosa had occurred in such a short time after the onset of symptoms indicated that the pathological process was rapidly progressive and there seems little doubt that conservative treatment would have failed to prevent its further progression by overcoming the obstruction and thus relieving the increased intravisceral tension by allowing escape of the contents through the cystic duct. The result of this failure would have been an increasing amount of interference with the blood supply due to increasing intravisceral tension leading to a spread of the gangrene to involve the entire thickness of the gall bladder wall, with subsequent perforation and extravasation of its contents. This catastrophe toward which the patient was being led rapidly by the swift progress of the lesion was, and could only have been, averted by timely surgical intervention.

The increased white cell count with a polymorphonuclear leucocytosis indicated that there was present an inflammatory element in the pathological lesion for obstruction alone would be unlikely to be responsible for such a change in the blood picture. The local inflammatory reaction, as shown by microscopic examination of the gall bladder was of a mild degree probably less than might reasonably have been expected in view of the white cell count. However there is no doubt that the general inflammatory reaction as indicated by the leucocyte count does not always bear a directly proportionate relationship to the amount of local reaction which may be present.

Because the microscopical findings showed only a mild degree of acute inflammation to be present inflammatory exudate could have played but a minor rôle in augmenting the visceral contents and so leading to the increased tension which developed within the gall bladder. It is reasonable to assume therefore that this feature was chiefly due to the transudation of fluid into the lumen consequent upon the compressions of the blood vessels in the wall by muscular spasms. In support of this assumption the agony suffered by the patient bore testimony to the intensity of the muscular spasms of the gall-bladder wall and

be experienced so little relief in between the colic like exacerbations that it seems probable that the musculature had passed into a state of tonic spasm upon which clonic spasms were superimposed from time to time. The corresponding severity of the vascular compression could readily have resulted in copious transudation of fluid from the congested submucosal and mucosal veins and capillaries.

As Rutherford Morrison pointed out many years ago the more bile the gall bladder contains when obstruction of its outlet occurs, the more rapid will be the progress of the pathological changes which follow as a correspondingly smaller amount of exudate or transudate will be sufficient to increase the intravisceral tension to an abnormal degree. The rapidly progressive character of the pathological changes in the present case indicating that the whole thickness of the wall would soon have become gangrenous had this termination not been forestalled by operation undertaken only 24 hours after the onset of the attack, supports Morrison's contention since the fluid found in the gall bladder at the time of operation was frankly bilious however much its original appearance or physical characters might have been altered by exudate or transudate from the mucosa, a fact indicating that much bile was already present in the gall bladder when obstruction occurred for no bile could have entered it from the common duct once this had taken place.

While the writer considers cholecystectomy preferable when operating upon a patient with acute obstructive cholecystitis if this procedure is not contraindicated by the presence of some general or local condition yet it should be remembered that the danger attending the presence of increased intravisceral tension can be averted through relief of this tension by cholecystostomy (this procedure imitating Nature's drastic and dangerous method of relieving it by perforation through a gangrenous area) and this comparatively simple operation is here warmly commended to any inexperienced surgeon into whose hands one of these patients should chance to fall—as is bound to happen from time to time. The operation of cholecystectomy is fraught with many potentialities for serious difficulties, and,

until a surgeon is sufficiently skilled and experienced to accept such responsibility, it should always be done under the supervision of a senior surgeon. To arrange for the presence of such a supervisor is not always possible and in his absence the surgeon who has not yet reached this state of operative proficiency would, under these circumstances, be well advised to remember that a living patient with a drained gall bladder is infinitely preferable to a dead one with that viscus removed.

**CASE 2** Mr W L S, aged 57 years. This patient was first seen at his home on March 29, 1941, suffering from an attack of biliary colic. The only sign of note was a tenderness over the gall bladder area, the temperature and pulse being normal. He gave a history of having had a somewhat similar, though milder, attack only once previously and that about 6 weeks before. His digestion had always been good except for occasional flatulence which had never caused him sufficient distress to seek medical advice. He had never been jaundiced. Under conservative treatment of rest in bed, an ice bag to the gall-bladder region, a fluid diet and control of pain by opiates, the attack subsided, the acute pain disappearing within a few hours and leaving in its wake the usual soreness in the right upper quadrant. By April 1 he was feeling quite fit again. On April 3 he was again stricken by biliary colic and when seen he appeared to be having a more severe attack than that from which he had suffered a few days previously. In addition to a marked tenderness over the gall-bladder area some rigidity of the abdominal musculature in this region had made its appearance. No mass was present. The temperature was 99 degrees F and the pulse 84. He was advised to enter the Cottage Hospital for observation. On admission some 2 hours later his temperature was found to be 98 degrees F, pulse 88, the urinalysis was normal, but the leucocyte count was 20,000 with 83 per cent polymorphonuclears. Later in the day his temperature rose to 101.4 degrees F and his pulse to 100. At this time he was actually feeling better, for the severe pain had passed off and examination of the abdomen revealed less tenderness and rigidity than when first seen earlier in the day and no abdominal mass was present. He had a good night and by morning his temperature had fallen to 98.4 degrees F and his pulse to 80, while his leucocyte count had fallen to 15,150 with 66 per cent polymorphonuclears. By the third day after admission all signs and symptoms had disappeared and he was feeling well. Cholecystography the following day revealed a poorly functioning gall bladder containing stones. When the patient was told of these findings and informed that operation would be necessary at some convenient future date for the cure of the condition, he wished, for economic reasons, to have the opera-

tion performed as soon as possible. It was undertaken on April 8, under general anesthesia, the peritoneal cavity being opened through a Kocher subcostal incision. The wall of the gall bladder was thickened, edematous, and reddish in color and, although the viscus was distended, it was not tense. Several old, string like omental adhesions were present, but the omentum itself, although lying in close proximity to the gall bladder, was normal in appearance and was making no attempt to envelop that viscus. Edema was also present around the cystic and common ducts. The common duct was not dilated nor was its wall thickened and so there appeared no indication for opening it. Cholecystectomy was performed and the gall bladder was found to contain multiple small, faceted calculi of the mixed type. The patient had an uninterrupted convalescence.

Microscopic examination showed a diffuse edema of all coats. A feature of the histological picture was the large number of mononuclear cells which were present throughout all layers but most abundant in the submucosa. In this layer numerous polymorphonuclear leucocytes were also to be seen.

This case was chosen as representative of the type in which the indications for operation, as outlined previously, did not develop during the attack and it was therefore unnecessary to operate at that time. In this respect it forms a distinct contrast to the first. The important point, however, is although operation in each of these two cases was undertaken at different stages of the disease, both patients were dealt with according to the principles of the rational treatment so that the time of operation in each case was decided essentially upon a knowledge of the pathology and its correlation with the symptomatology.

When the provisional diagnosis of acute obstructive cholecystitis was made on the history of biliary colic and the physical signs of tenderness and rigidity over the gall-bladder region together with some increase in the pulse rate and temperature, the patient was sent to hospital for further observation. The white cell count taken shortly after admission was interesting as it was higher than that in Case 1 although clinically the patient was not nearly so ill—a fact to which reference will be made later.

Later during the day of admission, when the temperature rose to 101.4 degrees F and the pulse rate to 100 beats per minute, any temporary progression of the pathological changes which these findings might have rep-



resented was not confirmed by clinical examination for both the tenderness and rigidity were less marked and the pain had diminished. Realizing that this clinical improvement might have been due to the opiates administered the effect of which was to mask a progression of the pathological process, *the absence of a palpable mass at this time* nevertheless led to the conclusion that even if the lesion was progressive it had not yet reached the stage when an immediate operation was to be regarded as necessary to relieve increased intravisceral tension, in other words the disease was still in the stage from which spontaneous recovery takes place in the majority of cases and we could rest secure in the knowledge that the patient's clinical manifestations were not perpetrating a costly deception upon us. The following morning, in which time any effect of the opiates upon the clinical manifestations could be disregarded, all signs and symptoms showed improvement (including a drop in the number of leucocytes to 15 000) unmistakably pointing to a retrogression of the pathological changes. This favorable course continued and the patient soon became completely free from symptoms. Thus the indications for immediate operation which sometimes develop in acute obstructive cholecystitis and for which we must always watch carefully did not appear so that the question of such an operation did not arise in this case.

The surgical intervention necessary for the ultimate cure of the condition would have been delayed for a greater length of time than it was, to allow of a maximal retrogression of the pathological changes in the gall bladder had it not been for the express wish of the patient to have it done as quickly as possible while he was still in hospital. Performed when it was, the operation provided an interesting opportunity for proving the correctness of deductions, and decisions made consequent thereon prior to operation in the light of the principles governing the rational treatment. In the first place the edematous and thickened wall of the gall bladder confirmed our opinion of pathological changes in this viscus as having been the cause of the patient's illness, but the clinical disappearance of symptoms, associated with the finding at operation

of a passive noninflamed omentum lying adjacent to the gall bladder led one to conclude that these pathological changes were then in a process of retrogression, although sufficient time had not yet elapsed to allow of its completion. This opinion was confirmed later by microscopical examination of the excised gall bladder. However the most striking feature about the viscus was that, though distended it was not tense indicating that there was no obstruction preventing the escape of its contents through the cystic duct. That obstruction was present in the early part of the attack we know for the biliary colic which the patient experienced was the result of Nature's effort to overcome or remove it. Thus one deduction to be drawn from the pathological process as it presented itself at operation, and corroborating that made on the clinical findings prior to this event is that the obstruction was relieved by natural means before the stage was reached that pathologically results in enlargement and tense distention of the gall bladder and that clinically is indicated by the development of the palpable mass which constitutes the most important indication for immediate operation to relieve the increased intravisceral tension and so avert the more serious terminations of the disease. The question naturally arises did the gall bladder reach this stage but could not be detected on palpation? Had it done so then the progression of the pathological changes which the attainment of this stage implies would certainly have given rise to the development of other increasingly severe signs and symptoms such as increasing rigidity, a continuous increase in the pulse rate and a deterioration of the patient's general condition none of which, however made its appearance. It might be stated here that no doubt there are some cases in which the gall bladder is situated so entirely under the liver that even when it has reached the stage of gross enlargement here referred to its fundal portion does not project sufficiently beyond the liver margin to be detectable on palpation. In such cases, however a mass will still make its appearance and although due to the omentum enveloping the gall bladder in its endeavor to exclude this pathological viscus from the general peritoneal cavity yet its

presence at once gives valuable information concerning the condition of the gall bladder, for it will be unlikely to develop unless the pathological changes in this organ have already reached the dangerous stage of gross enlargement with acutely increased intravisceral tension. Moreover, in such cases this mass will usually appear in time to allow of the more serious terminations of the disease to be averted by surgical intervention, provided its development is correctly interpreted as indicating the advisability of such treatment.

Microscopic examination of the gall bladder showed the presence of a resolving acute inflammation (as indicated by the infiltration of large mononuclear cells) but enough evidence of the acute reaction was still present to indicate first, that it must have been quite marked early in the attack and, in addition, that the inflammatory element was definitely more predominant in this case than in Case 1. Yet the first patient, with the milder inflammatory changes in the gall bladder, rapidly became very ill and had to be operated upon as an emergency measure, while the second in whom these changes were more marked recovered spontaneously from his attack. What factor, then, determined an outcome in each case contrary to that which could reasonably have been expected if inflammation, *per se*, could have decided the issue? The answer to this question is, *obstruction of the outlet of the gall bladder*. We know that in both cases obstruction occurred, for each was the subject of biliary colic which, as mentioned previously, is caused by the forcible contractions of the smooth muscle in the gall-bladder wall and constitutes Nature's method of trying to overcome obstruction in a hollow muscular viscus, *but the essential difference between the 2 cases is that in the first the obstruction persisted while in the second it was relieved early by natural means*. The outcome in the first case was that the intravisceral tension rapidly increased and interfered so quickly with the blood supply to the gall bladder that gangrene of the mucosa had already occurred when operation was undertaken only 24 hours after the onset of the attack, in the second, the natural relief of the obstruction (as indicated by the cessation of colic) permitted the escape of exudate and transudate, poured out from the mucosa into the lumen, through the cystic duct, thus averting the danger, so well exemplified in the first case, of increased intravisceral tension and its serious consequences, and the patient recovered from the attack without surgical intervention having become necessary. These two representative cases illustrate well not only the importance of obstruction of the outlet of the gall bladder as a factor in determining the outcome of the disease but indicate also that, in the absence of obstruction, the inflammatory element is of minor importance as it is unlikely to terminate seriously. It was this important rôle played by obstruction that led the writer to suggest "acute obstructive cholecystitis" as the most suitable designation for the condition under consideration and he would like to state that at the time when he made this suggestion he was unaware that Mentzer had already done likewise in 1936 and thus inadvertently failed to acknowledge that author's priority in this matter. The paucity of references to the condition by this name subsequent to that date would appear to indicate that Mentzer's suggestion unfortunately was not received with any degree of enthusiasm for, as well as being correct terminology, it also serves the additional purpose of forcefully reminding the surgeon of this factor which is of such great importance in the etiology and prognosis of the disease.

#### OBSERVATIONS FROM STUDY

It is hoped that the presentation and discussion of these 2 cases have not only achieved their aim of illustrating the practical application of the principles of the rational treatment but have also shown that the correlation of the symptomatology with the pathology is a *sine qua non* if this application is to be carried out successfully. At this point, therefore, the writer wishes to draw attention to the fact that there have appeared in the literature from time to time articles describing cases in which advanced disease was found at operation while the clinical manifestations were minimal or even absent, the result of such reports being to promote the belief that the degree of the pathological process present in acute obstructive cholecystitis often bears no

direct relation to the symptomatology Heuer for example states "A study of the relation ship between the clinical symptoms of acute cholecystitis and the pathologic course of the inflammatory process in the gall bladder shows that there is no direct parallelism between them—in other words, that the clinical symptoms exhibited by the patient do not give any certain indications of the course of the pathologic process in the gall bladder—whether this be toward restitution or toward gangrene and perforation. This belief accepted apparently as it is by many surgeons, is responsible for much of the confusion which exists at the present time regarding the treatment of this condition, for if this belief were correct, it would naturally be impossible to know what are the clinical manifestations which indicate that operation should be performed if the progression of the disease to its more serious terminations is to be prevented, with the result that we would have no means by which to determine whether or not, or when, it should be undertaken to accomplish this purpose. But this confusion should not exist for it is based upon a wrong premise since as illustrated in particular by these 2 representative cases a very distinct parallelism usually does exist between the pathology and the symptomatology and because this is so the clinical manifestations which indicate the need for operation are definite and recognizable and have already been described by the writer. However it is obvious that this parallelism can only be discerned if the pathological process is understood and conversely failure to discern it implies a lack of this understanding.

It has been the humbling experience of the writer on occasions to find that reconsideration of a mistaken diagnosis has proved this to be due either to ignorance of the underlying lesion or the symptomatology or to failure or lack of care to have observed or evaluated properly one or more clinical manifestations. He believes that similar shortcomings on the part of others are largely responsible for the placing in the "atypical" category of many of the cases of acute cholecystitis reported as such.

Where such cases as these have been reported there do not seem to have been any at

tempts made to explain what are considered to be discrepancies between the extent of the pathological changes and the symptomatology. In fact the attitude usually adopted has been to regard them as inexplicable vagaries of Nature. However the writer believes that, in many cases, they are more apparent than real and offers the following discussion in support of his opinion.

The gall bladder is a hollow muscular viscus and sudden obstruction of its outlet is the stimulus which causes its unstriated muscle to contract forcibly in an effort to overcome the obstruction these forcible contractions of the unstriated muscle giving rise to biliary colic. Should the obstruction be relieved as, for example by the extrusion of a stone into the common duct or by its falling back into the gall-bladder cavity the stimulus causing these forcible contractions is removed and they will cease no further clinical manifestations marking their appearance. If on the other hand, the obstruction is not relieved, then after a prolonged and intense effort over a variable period exhaustion of the muscular walls will follow the violent spasmodic contractions abate and relief from the severe pain results and *this in spite of the fact that the gall bladder is still obstructed.* When acute inflammation is superadded to such an obstructed gall bladder then the intravisceral tension begins to increase bringing in its train the pathological changes which have already been described. Hence there can be a stage in acute obstructive cholecystitis in which the classical severe pain is absent and the patient consequently feels better *yet the pathology is progressive.* This stage may last for hours or days before gangrene finally supervenes, depending upon the rapidity of increase of the intravisceral tension but during this time *the distended gall bladder will become palpable* (if it has not already done so before the cessation of the pain) and thus indicate clearly the progressive nature of the pathological process. *That such a stage can exist is a further cogent reason for advising operation without delay once the gall bladder has become palpable.*

When gangrene occurs, the nerves in the wall of the gall bladder share this fate along with the other tissues. Dead men tell no

tales" and with the pain reflex-arc thus destroyed a period of delusion may follow, when the patient feels much better and at this time the surgeon may be deceived into believing that a retrogression of the pathological process has occurred. The same is true of the appendix, and there must be many surgeons who have encountered the deceptive lull in the symptoms, accompanied by return of a feeling of well-being, which often precedes the severe pain heralding the onset of perforation of a gangrenous appendix, *although in the case of the gall bladder the presence of a palpable, and therefore pathological, viscus should act as a deterrent against this deception.* When the gall bladder is the viscus affected, this lull is often of much longer duration because its edematous walls are much thicker so that perforation does not occur so readily, and the additional time thus given the omentum to play its rôle of abdominal policeman enables it to form a more efficient barrier against a free perforation into the peritoneal cavity. The writer is of the opinion that in acute obstructive cholecystitis the occurrence of gangrene in the absence of a markedly increased intravisceral tension, as indicated by a palpable gall bladder, must be exceedingly rare and he has never seen a case of gangrene except in its presence. Intramural infection alone is unlikely to be diffuse or severe enough to produce it.

Mention is sometimes made of unusual cases in that the presence of a palpable gall bladder, found at operation to be the seat of advanced acute cholecystitis, was unaccompanied by rigidity of the overlying musculature. We know that such rigidity represents the reaction of the abdominal muscles to irritation of the parietal peritoneum and in such a case, therefore, its absence can only be explained by protection of the parietal peritoneum from contact with the inflamed serosa of the gall bladder. The agent responsible for this is the omentum, *which will be found enveloping the gall bladder in all such cases,* the inflammatory process involving its inner surface in contact with the gall bladder not having yet spread by continuity of tissue through its substance to involve its outer surface in contact with the parietal peritoneum. (However if and when its outer surface does be-

come involved, then the parietal peritoneum will become irritated by contiguity and rigidity of the overlying muscles will make its appearance.) In such a case, then, the pathological process can be progressive although there is no rigidity of the overlying muscles, *but against the guide to the pathological situation is the palpable mass,* the significance of which is in no way altered by the fact that rigidity is absent.

While it is not claimed that the above considerations entirely solve the problem of the "atypical" case of acute obstructive cholecystitis, that is, one in which a lack of relationship appears to exist between the pathology and the symptomatology, yet it is felt that if many of these considerations, this relationship would readily become evident. They also indicate how the development of a palpable mass in the right upper quadrant, if only its pathological significance is understood, will often provide the solution to what may appear, in the event of failure to interpret its significance correctly, to be a perplexing clinical problem. *Too much emphasis cannot be laid on the fact that in this disease the significance of this palpable mass remains unaltered no matter to what extent apparent lack of confirmation by other signs and symptoms may seem to deny its import.* Consequently it is felt that this finding should be regarded as the most important single clinical manifestation in acute obstructive cholecystitis.

The writer, therefore, feels that any surgeon, armed with the knowledge of the pathology and symptomatology of acute obstructive cholecystitis, cannot but disagree with the statement, encountered repeatedly in the literature, that these two aspects of the disease often bear no direct relationship to one another. It is unfortunate that this statement, by having been allowed to pass so long unchallenged, has gained such wide acceptance, since it is not only misleading but no less to be deplored than this is the adverse influence which such teaching cannot fail to exert upon the thinking of the young surgeon who, in striving to reach some conclusions about this disease, already finds himself confused by the diversity of advice offered him in the litera-

ture for it contains the erroneous implication that any attempt to outline a rational treatment is foredoomed to failure and in addition tends to discourage him still further by giving the impression, as perturbing as it is incorrect that the subject is one beset with insurmountable difficulties.

#### SUMMARY

1 The pathology of acute obstructive cholecystitis and the principles governing the rational treatment of this condition are described briefly

2 Two representative cases of this disease are presented and discussed in order to (a) illustrate the practical application of these principles to the individual case and (b) show how a knowledge of the pathological process enables the observer to correlate it with the symptomatology and thus to follow clearly the progress of a case

3 Attention is directed to the statement often encountered in the literature that in this disease there is often no direct relationship between the pathology and the symptomatology

Certain points are discussed to show that in many cases such discrepancies may appear to exist between these two aspects of the disease are readily capable of explanation. Consequently this statement is considered erroneous and mention is made of its harmful effect upon the surgical teaching of this disease

4 The importance of the development of a tender, palpable mass in the right upper quadrant of the abdomen during the course of the disease is again emphasized for the crucial significance of this clinical sign remains unaltered no matter to what extent apparent lack of confirmation by other signs and symptoms may seem to deny its import.

#### REFERENCES

1. DENTON, J. *Arch. Surg.*, 1924, 4, 3.
2. HERRIN, G. J. *Ann. Surg.*, 1937, 70, 753-762.
3. KASZDAN, F. G. *Surg. Gyn. Obst.*, 1932, 57, 473-485.
4. MORTIMER, E. H. *Surg. Gyn. Obst.*, 1936, 6, 833-846.
5. MORTIMER, E. H. *Edinburgh M. J.*, 1935, Oct. Reprinted in *Surgical Contributions*, Vol. (Windsor: J. H. B. & Sons), p. 657.
6. BURR, J. H. *Surg. Gyn. Obst.*, 1913, 73, 212-217.

# CHANGES IN EXTRACELLULAR WATER AT DELIVERY AND IN THE PUERPERIUM

LEON C CHESLEY, Ph D, and JANET M BOOG, M D, Jersey City, New Jersey

IT is well known that normal pregnancy is accompanied by a progressive gain in weight of the mother which is two to three times greater than can be accounted for by the growth of the conception product. When this total weight gain is less than 20 to 25 pounds, the mother usually returns to her pre-pregnancy weight early in the puerperium (Waters). Associated with this puerperal weight loss there is characteristically a diuresis. This has led to the inference that in pregnancy there has occurred a hydration of the maternal tissues, and that after delivery this water is mobilized and excreted.

In a previous paper (3) we have shown that normal pregnant women do gain an average of 9 to 10 pounds of extracellular water, exclusive of that in the conception product. Individual cases varied widely, and under salt restriction the changes in volume of extracellular water were markedly affected.

In the present study we have determined the changes occurring in the volume of extracellular water during delivery and the puerperium, and correlated these changes with changes in body weight. Incidentally we have made observations on the distribution of thiocyanate as between maternal serum on one hand, and cord serum, amniotic fluid, placental tissue, and milk on the other.

## MATERIAL AND METHODS

We have described elsewhere (6) the details and limitations of our measurements in pregnancy of thiocyanate-available water (roughly equivalent to extracellular water). Briefly, on the assumptions that sodium thiocyanate is confined to, and evenly distributed in, extracellular water, one can calculate the volume of that water by dividing the serum concentration of thiocyanate into the amount of thiocyanate in the body.

In measuring the thiocyanate-available water, in the present study, we proceeded as follows. Normal patients in early labor and with intact membranes were weighed and given 1000 milligrams of sodium thiocyanate intravenously. All urine was saved until the time of delivery, in order to determine the renal excretory loss of thiocyanate. Immediately postpartum (minutes) a blood sample was taken for analysis, and a second 1000 milligrams of sodium thiocyanate was injected. Four hours later a second blood sample was taken, and the postpartum urine collection ended. On the 6th and 10th days postpartum the patients were weighed, and the measurements were repeated. The determination of available water was usually repeated again at 6 weeks postpartum. On all of these occasions, blank blood samples were taken before the injection of the 1000 milligrams of sodium thiocyanate, and blank urines were collected over a known period of time prior to the test. Four hours after the thiocyanate injection, except for the antepartum measurement, blood samples were taken and urine collections were ended.

All of the amniotic fluid was caught and measured, and the concentration and quantity of thiocyanate therein was determined. The blood loss was measured, and the fetus, placenta, and membranes were weighed. The concentration of thiocyanate was determined in the cord blood and in the placental tissue. The last named measurement was paralleled by the determination of the total water concentration of the placenta (by exsiccation).

In the placental analyses, the cord and sac membranes were removed, the stagnant blood was gently pressed out of the large veins, and the placental surfaces were sponged dry. The placenta was then cut, pie-wise, into thirty-seconds. Every fourth sector was taken for the water and thiocyanate determinations. The membranes were stripped off and the

pieces were finely minced together with scissors and then ground with a mortar and pestle. Total water was determined by spreading out weighed quantities of ground tissue in thin layers on watch glasses, and then drying to constant weight at a temperature of about 90 degrees C. For thiocyanate determination, ground tissue was extracted for 24 hours with nine times its weight of 0.9 per cent aqueous sodium chloride. Proteins were then precipitated with 50 per cent trichloroacetic acid added in a 2:1 ratio (by volume). Thiocyanate was then determined in the filtrate.

The tests were not completed if the patient delivered in less than 4 hours or more than 24 hours after the initial thiocyanate injection. We excluded patients showing blood pressure elevations at any time or developing febrile morbidity. In some cases patients were excluded because they received infusions. When accurate collections of amniotic fluid and blood loss were not made the tests were discarded. Also patients having abnormal deliveries were excluded. Anesthesia was minimal and usually consisted of gas and oxygen, often with ether. In order to fulfill all of these conditions, we were able to finish the tests on only about one fourth of the cases begun. In all, complete studies were made in 16 patients. In an additional 24 patients we measured the puerperal losses of water by determining the extracellular water immediately after delivery and again at 6 days and at 6 weeks post partum.

Thiocyanate was determined in duplicate in serum, urine, amniotic fluid, milk, and placental filtrates by a photoelectric method described elsewhere (4). Chlorless crystal clear filtrates were made from urine, amniotic fluid and milk by adding an equal volume of 10 per cent sodium tungstate solution containing about 5 per cent of serum protein, followed by eight volumes of twelfth normal sulfuric acid.

**Calculations.** In the first measurement of available water the serum concentration of thiocyanate was divided into the quantity of thiocyanate left in the body (Initial 1000 milligrams minus the urinary loss). Thus in addition to the mother's extracellular water the antepartum measurement includes (1) the

available water of the fetus and placenta, and (2) a variable amount of amniotic fluid depending upon (a) the time elapsed from the thiocyanate injection to delivery and (b) the volume of amniotic fluid.

In subsequent measurements of available water the calculation was somewhat more complicated. The urinary loss of thiocyanate residual from previous tests was determined over a 4 hour period just before the new injection. This loss was assumed to continue in the same magnitude during the 4 hours after the new injection and was subtracted from the total thiocyanate loss during that period. Thiocyanate was determined in the blank serum taken just before the injection, and again in the serum taken 4 hours later. The rise in serum thiocyanate was then divided into (1000 milligrams minus corrected urinary loss of thiocyanate). Serum thiocyanate was determined in both the blank and the test sera independently and the rise was checked by using the blank to obtain the "center setting" for the Evelyn photoelectric colorimeter and by reading the test serum directly. These two ways of measuring the rise in serum thiocyanate always checked very closely.

## RESULTS

The data for the first 16 cases are summarized in Table I.<sup>6</sup> It will be seen that the major decreases in weight and in available water occur at delivery and in the first 6 days postpartum.<sup>7</sup> (Case 6 does not conform to the rule, in that she lost no water in the early puerperium. However she had been on a low salt diet for more than a month before delivery.) From the 6th to the 10th days post partum the weight drops only slightly while the available water remains essentially unchanged.<sup>8</sup> The changes between the 10th day and 6th week postpartum are variable but in all cases further loss of water does occur. There seems to be no correlation between the total weight gain in pregnancy and the water and weight loss in the puerperium. This is to be expected, since all but one of the patients had normal proportions of available water antepartum; the one exception (Case 4) had an extracellular water volume only slightly above the upper limits of normal.

TABLE I—THE CHANGES IN WEIGHT AND IN AVAILABLE WATER DURING DELIVERY AND THE PUERPERIUM

Case Age Para	Weight in pounds			Available water in liters					Weight, in kilograms				
	Before preg nancy	p p. 10 days	Gain in preg nancy	a.p. 0 days	p p 0 days	p p 6 days	p p. 10 days	p p. 6 wks	a.p. 0 days	p p 0 days	p p. 6 days	p p 10 days	p p 6 wks
1 23 I	98	99.5	18	18.52	17.04	13.56	14.51		5.73	47.52	45.68	45.22	45.22
2 24 I	128	131.5	23	22.70	21.36		16.12	15.45	68.86	63.78	60.91	59.77	61.82
3 18 0	113	120.0	17	18.22	16.73	15.40	14.12	13.67	59.30	54.93	55.91	54.55	
4 21 0	134	135.5	21	26.90	24.50	19.25		16.87	70.65	65.85	61.59	61.59	60.23
5 19 I	110	117.0	20	19.40	18.50	15.16	15.43		50.31	55.83	53.41	53.18	
6 20 0	120	140.5	35	19.18	17.12	17.87	17.44	15.45	70.34	66.12	64.66	63.86	
7 15 0	108	107.0	13	18.98	18.10	16.20	16.82	15.22	55.22	51.02	48.64	48.64	49.54
8 22 III	108	119.7	27	18.84	18.07	15.72	16.17	14.02	61.59	56.84	55.45	54.43	56.82
9 18 0	134	153.0	34	24.03	22.77	19.45	19.97		76.36	71.44	69.32	69.53	
10 20 I	150	155.0	20	24.00	21.72	18.45	18.40	17.70	77.50	73.95	70.91	70.45	71.36
11 20 0	112	120.0	21	19.94	18.43	15.41	15.48	14.47	60.45	56.97	55.45	54.54	55.91
12 27 0	100	104.0	15	17.58	15.62	13.91		11.68	52.27	48.45	47.27	47.27	44.55
13 21 0	115	132.5	34	22.12	19.30	16.66	16.36	14.92	67.73	61.88	60.23	60.23	59.09
14 27 0	100	98.5	15	18.16	16.48	14.14		11.77	52.39	48.45	46.02	44.77	42.96
15 20 III	103	116.0	34	20.48	17.95	15.02		13.87	62.16	55.51	52.73	52.73	
16 18 0	128	135.7	26	22.69	20.51	18.15	17.82	16.38	70.00	64.57	61.36	61.70	61.36

A p., antepartum p p. postpartum.

The loss of available water at delivery A detailed analysis of the delivery loss of available water is presented in Table II, without taking account of water of transpiration. We arrived at the "calculated loss of available water" (columns 2, 3, 4, 5 and 6 of Table II) from the following considerations. When available water is calculated, one divides the

serum concentration of thiocyanate into the quantity of injected thiocyanate remaining in the body at the time the serum sample is taken. If the concentration of thiocyanate in the water at any site is less than that of the serum, then not all of that water is included in the measurement. If, for instance, the concentration of thiocyanate in amniotic fluid is



TABLE II.—THE LOSS OF AVAILABLE WATER AT DELIVERY

Patient	Loss of available water at delivery in ml.					Discrepancy (calculated minus measured)	Weight lost at delivery gms.	% of delivery weight loss at available water		
	Calculated loss of available water								Deficiency (a-p) measurement(s)	
	Amniotic fluid	Blood loss	Placenta	Fetus	Total					
	345		22	913	1280	14%	-430	- 67	5 11	34
	514	90	390	403	1497	20	-680	-2 90	68	26
			463	861	1324	300	70		27	31
	304	16	475	1000	1895	1,000	300	90	80	24
	230	34	25	892	1281	000	-470	-2 10	25	23
6	460	105	136	750	1451	2000	230		15	20
	577	41	134	840	1692	830	-600	- 11	80	26
8	477	30	390	930	1827	770	-1300	-3 47		37
	409	165	304	58	1136	000	-590	- 10	46	36
10	400	41	463	802	1706	1530	40			20
	98	94	34	66	292	570	70	3	26	36
12	40	34	190	790	1154	1000	160	30	21	25
	370	21	14	902	1307	1000	67	76	63	27
14	327	14	36	800	1177	1500	60	7	64	20 8
	308		400	1053	1761	1770	10	76	8 53	22
16	644	41	436		1121	130	30		43	30
A	150	18	070	806	1044	1730	-600	-0 04	4 67	17

45 per cent of the concentration in the maternal serum then 45 per cent of the amniotic fluid volume is included in the antepartum measurement of available water i.e. the volume of amniotic fluid is multiplied by the ratio  $\frac{\text{concentration of thiocyanate in amniotic fluid}}{\text{concentration of thiocyanate in maternal serum}}$

The available water of the placenta was calculated in the same way from analyses of the thiocyanate concentration in placental tissue. The blood loss at delivery was multiplied by 0.827 to obtain the available water loss. (Oberst and Plass found that the water content of the whole blood in late pregnancy averages 82.7 per cent. All of the blood water intracellular as well as extracellular is available to thiocyanate according to Crandall and Anderson.) The available water of the fetus was assumed to be 30 per cent of the body weight this assumed volume was corrected by multiplying with the ratio

$\frac{\text{concentration of thiocyanate in cord serum}}{\text{concentration of thiocyanate in maternal serum}}$

The calculated loss of available water at delivery averages 1.74 liters (3.80 pounds) which represents 37.0 per cent of the average weight loss of 10.3 pounds. In individual cases, the calculated loss often does not check very closely with the loss as determined by difference between antepartum and postpartum measurements. We are of the opinion, however, that the calculated loss may be the more reliable because errors of several hundred milliliters could result from small percentage errors in the measurement of available water volumes averaging 21,000 milliliters. In column 8 of Table II we have presented the discrepancies between the calculated and measured losses in available water. When these discrepancies are related to the total volumes measured the percentage is seen to be small enough usually to fall within the range of error of the test (column 9).

The range of error in the determination is considered to be about  $\pm 2.0$  per cent. The chemical measurement of the thiocyanate is accurate within  $\pm 1.0$  per cent (4) or probably less since duplicate determinations were re-

TABLE III—ANALYSIS OF DELIVERY AND PUERPERAL WATER LOSSES

Case	Total weight of water lost pounds		Water lost at delivery		Water lost in first 6 days postpartum			Water lost between 6 days and 6 weeks postpartum			Ratio* of water loss to weight loss
	a p to 6 weeks p p	Puerperium only	Pounds	Per cent of total water loss	Pounds	Per cent of total water loss	Per cent of puerperal water loss	Pounds	Per cent of total water loss	Per cent of total water loss	
1			3.23		7.60						1.09
2	15.85	12.92	2.03	18.5	11.46	72.3	88.7	1.46	9.2	11.3	3.00
3	9.04	6.68	3.26	32.8	2.92	20.2	43.5	3.76	38.0	56.5	6.83
4	21.95	16.71	5.24	23.9	11.49	52.4	68.8	5.22	23.7	31.2	1.35
5			1.97		7.30						1.15
6	9.04	4.54	4.50	55.2	Gain (0.75)			5.29	64.7	145.0	
7	8.21	6.28	1.93	23.4	4.15	50.6	66.1	2.13	26.0	33.9	1.93
8	10.54	8.86	1.68	16.0	5.14	48.8	58.0	3.72	35.2	42.0	202.5
9			2.75		7.26						1.47
10	13.76	8.78	4.98	36.4	7.15	51.9	81.4	1.63	11.7	18.6	2.36
11	11.96	8.66	3.30	27.6	6.60	55.2	76.2	2.06	17.2	23.8	3.71
12	12.90	8.62	4.28	33.2	3.74	29.0	43.4	4.88	37.8	56.6	1.01
13	15.73	9.57	6.16	39.2	5.77	36.7	60.3	3.80	24.1	39.7	1.56
14	13.96	10.29	3.67	6.3	5.11	36.6	49.7	5.18	37.1	50.3	0.86
15	14.45	8.92	5.53	38.3	6.41	44.4	71.9	2.51	17.3	28.1	1.06
16	13.80	9.03	4.76	34.5	5.17	37.4	57.2	3.87	28.1	42.8	1.28
Av of all			3.80		6.03						
Av of complete cases	13.24	9.22	4.02	30.4	5.72	43.2	62.1	3.50	26.4	37.9	1.62

\*Ratio calculated from last simultaneous measurements of weight and available water (see Table I)

quired to check within 0.04 milligrams per 100 milliliters. The injection of 20 milliliters of the thiocyanate certainly entails some error. An error of 1 per cent would allow a deviation of 0.2 milliliters in the volume injected.

*The loss of available water postpartum.* Tables III and IV summarize the puerperal loss of available water. As already mentioned, the major loss in weight and available water occurs in the first 6 days postpartum. This accords with Bray's study of puerperal weight loss.

It is interesting to compare the water loss with the weight loss (Table III) in the light of our previous suggestion (7) that normally, in late pregnancy, intracellular water may shift out into the extracellular spaces. As Table III shows the weight of available water lost is greater than can be accounted for by the weight loss. This would suggest that some of the water is still in the body, but is no

longer available to thiocyanate, i.e. some of the water may have re-entered the cells.

The average weight of water lost from just after delivery to the 6th day postpartum averages 5.02 pounds. Bray has analyzed the puerperal weight loss day by day in 64 women. By the 6th day postpartum the average weight loss was about 2.6 kilograms. If we assume the same proportionality between weight loss and available water loss (1:1.28) as found in our patients, the average weight of water lost would be 7.3 pounds in Bray's patients as compared with 5.02 pounds in ours. If the same calculation is applied to the data of Stander and Pastore who found an average weight loss of 2.3 kilograms in the first 10 days postpartum, the water loss is found to be 6.5 pounds.

From the 6th to 10th days postpartum, the changes in extracellular water were insignificant.

TABLE IV.—PUERPERAL LOSSES OF EXTRACELLULAR WATER IN SECOND SERIES OF PATIENTS

Case Age Par	Weight in pounds			Puerperal water loss				
	Before preg- nancy	Post- part- um days	Gains preg- nancy	Total pounds	First 6 days		Each day in weeks	
					Pounds	Per cent of total	Pounds	Per cent of total
1 1	122	30	73			70	30	39.3
13 11	130	150		28	0.31	87	0.4	
1 1	11	11	73	14	20		Gain 0.9	
20 11	96	96	30	24.57	36	63	18	14
21 16	70	1.26	73		13	34	0.64	63
21 16	96	34	1.8	Gain 30	Gain 64		0.3	
1 10	118		71	91	70	70	0.5	61
14 10	1203		71	0	80	30		41
23 14	724	1.00		0.80	15	77	0.6	84.6
26 19	11	30	77	47	4	18.0	2.1	41
27 11	1.15	17	30	07	80	13	47	40.6
28 10	11	1.30		64			Gain 30	
29 19	1004	1006		30.27	0.60	0		16
30 11	1.7	1.20	71			30	70	60.6
A					33	13.0	0.6	
Grand by Latham III & IV				0.30	30	60	13	39

From the 10th day to the 6th week post partum, all but 3 of 27 patients lost extracellular water often in the face of small gains in body weight. (Since many of the 6 weeks tests were done in the patients' homes we do not have all of their weights for this time.)

The average weight of extracellular water lost between the 6th day and the 6th week postpartum was 3.28 pounds, or 39.5 per cent of that lost after delivery and about 26 per cent of the total water loss from just antepartum to 6 weeks postpartum.

*The distribution of thiocyanate between maternal blood and the conception product. (1) Cord serum-maternal serum.* The concentration of thiocyanate in cord serum was always less than that in maternal serum. The proportion ranged from 82.3 to 99.4 per cent, and averaged 90.1 per cent; all but 4 values fell between 86 and 95 per cent. This accords with the work of Lavieta and associates, who compared the concentration of thiocyanate in serum with the concentration in effusions and edema fluid. They found that in the effusion fluid the concentration of thiocyanate averaged 90 per cent of that in serum, with the proportion ranging from 70 to 95 per cent (or excluding two extreme cases, the range was 86 to 93 per cent). They made ultrafiltrates of serum, *in vivo*, and found that the concentration of thiocyanate in the ultrafiltrates was less than that in serum by about the same proportionality. They therefore suggested that part of the thiocyanate was "bound" in the serum (plasma). In a later paper Rosenbaum and Lavieta adduced evidence for the existence of a lipid thiocyanate complex in plasma and serum. Such a complex would prevent the free diffusion of thiocyanate and therefore (together with the Donnan effect) would prevent the establishment of equal concentrations of thiocyanate in serum (or plasma) and their ultrafiltrates *in vivo* or *in vitro*. Apparently this lipid thiocyanate complex prevents the establishment of equal concentrations of thiocyanate on both sides of the placenta.

*2. Placental tissue-maternal serum.* The concentration of thiocyanate in placental tissue ranged from 7.5 to 79.3 per cent of the concentration in the maternal serum (excluding one case in which the proportion was unaccountably low at 59.9 per cent). The average proportion was 76.0 per cent.

The total water content of the placenta was very consistent from case to case; the range being 81.9 to 83.12 per cent (none excluded).

Assuming that all of the placental thiocyanate is distributed in the placental water, we find that the concentration would average 92 per cent of that in the maternal serum. It would appear, therefore, that thiocyanate freely enters the cells of the placenta, and that all placental water is "available" to thiocyanate.

3 *Amniotic fluid-maternal serum* The amniotic fluid thiocyanate concentration rises progressively with time, as Figure 1 shows. While we do not have enough cases to decide, it appears that larger volumes of amniotic fluid show somewhat slower rises in thiocyanate concentration (reasonably enough).

Flexner and Gellhorn have studied the rate of exchange of water and sodium between the maternal circulation and the amniotic fluid in the guinea pig. They found that the rate of water exchange was such that the amniotic fluid water might be completely replaced about once an hour, while the exchange of sodium went on at a rate fifty times slower. In our patients, the rate of entrance of thiocyanate into the amniotic fluid would be roughly comparable with the rate of sodium exchange in the guinea pig.

4 *Breast milk-maternal serum* In 14 cases we have determined the ratio of thiocyanate concentration as between breast milk and maternal serum. These ratios varied from 0.06 to 0.24 except for one at 0.52. Two-thirds of the ratios fell between 0.14 and 0.19. In each patient the ratio was the same at 4 hours as at 24 hours after the thiocyanate injection, and was the same for milk taken before nursing as for that taken after. In those patients having determinations at 6 days and again at 10 days, there was no difference between the ratios on these days. We have no explanation for the relatively high ratio found in the 1 patient, who incidentally was a poor milk producer.

#### ANALYSIS OF STUDY

In a study of the rate of gain in available (extracellular) water throughout normal pregnancy, we (3) concluded that the total volume increase averaged about 6.3 liters (13.7 pounds) with wide variations from case to case. Of this, we tentatively assigned 1500 to 2000



Fig. 1 The relation between thiocyanate concentrations in amniotic fluid and serum as a function of time elapsed from the injection of thiocyanate until the rupture of the membranes.

milliliters (3.3 to 4.4 pounds) to the conception product, leaving roughly 9 to 10½ pounds for the hydration of maternal tissues.

In general, the data of the present study are in accord with our previous conclusions. The total loss of available water from just before delivery to the 6th week postpartum averaged 6.06 liters (13.24 pounds), and of this an average of 1.74 liters was found in the amniotic fluid, placenta, and fetus (Tables II and III). Table III shows an average puerperal loss of 4.22 liters, or 9.22 pounds of extracellular water which had presumably contributed to the hydration of maternal tissues. However, this average water loss is lowered by the inclusion of the additional patients shown in Table IV. For the combined series of 27 patients, in whom complete postpartum studies were made, the average puerperal loss of extracellular water becomes 3.85 liters, or 8.30 pounds. As was pointed out in the earlier study (3), there is a very wide variation from patient to patient in the amount of water gained during pregnancy (and lost postpartum). One of our patients (Case 22) actually gained extracellular water after delivery. However, she had been on a low salt diet for 4 months.

This average of 8.30 pounds of water of hydration falls a little short of our previous estimate, but as we pointed out in that paper, the weight loss which often precedes the onset of labor may be associated with the loss of some extracellular water. Evidence for this is seen in certain patients of a series reported

elsewhere (7) There were 11 patients in whom measurements of extracellular water had been made at the 36th to 37th week of gestation and again within a day or two before the onset of spontaneous labor. In all but 3 of these there had occurred a loss in water and in 2 of the 3 exceptions the gains were very slight. Since the average rate of gain in available water in the last 6 weeks of pregnancy is about 110 milliliters per week it would seem that these patients might have lost from 600 to 900 milliliters of water just before the onset of labor. Such a loss, added to the measured losses described in the present study would balance nicely with the estimated gain previously described.

As is clear from Table III, the major loss of water in the puerperium occurs in the first 6 days. Indeed 60 per cent of the total puerperal loss occurs within this time. (Since we have not determined the available water after the 6th week postpartum we are not certain whether further loss occurs.)

Our interest in measuring extracellular water in pregnancy was originally stimulated by a desire to separate the water-gainers from the protoplasm-gainers, among patients who had shown rapid or excessive weight increments (6). We were not certain that our measurements always did this, since the possibility of intracellular water retention could not be eliminated and the test differentiated only between gain in extracellular water and gain in something else. The puerperal weight losses in the patients of the present series have some relevance for this question.

It seems improbable that water was retained antepartum in the cells of the normal patients who were used in the present study unless such retention persisted beyond the 6th week postpartum. The basis for this statement is the fact that the weight of extracellular water lost in the puerperium was always greater than the loss in the body weight. This disparity suggests that postpartum the cells may gain water rather than lose it. This might mean that antepartum the cells had lost water to the extracellular space—a suggestion which we have previously offered (3, 7) as a possible explanation for certain observation made in late pregnancy.

We can account for most of the normal weight gain of 20 to 25 pounds in pregnancy when we add the weight of extracellular water gained in the maternal tissues to the weight of the conception product. The fact that this added extracellular water is lost in the puerperium accounts for Waters' observation that patients with such normal weight gains usually return to their prepregnancy weights by the 6th week postpartum. Patients with larger weight gains may or may not return to their prepregnancy weights, depending upon what constitutes the excessive gain. When the excessive gain is water that water is quickly lost after delivery. If the excessive gain is protoplasm, then the patient usually will not return to her initial weight. This is illustrated by Cases 6, 8, 9, 13 and 15 in the tables. These patients had normal proportions of available water antepartum, and therefore their excessive weight gains were partly protoplasm which they still kept after the postpartum adjustment of the water balance.

It has long since been surmised that pregnant women do store water in their tissues and the familiar and characteristic postpartum diuresis has been interpreted as evidence for such storage and for the early puerperal diuresis of the stored water. Crabtree in a semiquantitative approach to the problem compared the fluid intake with the urine volume output in puerperal women. He found negative water balances of considerable magnitude, which would have been still greater with the inclusion of the water of transpiration of the milk, and of the lochial discharge. Taylor, Warner and Welsh found a negative sodium balance in 3 postpartum women. The losses of sodium were 4.00, 4.08 and 6.59 grams in the first 10 days after delivery. Since potassium balances were not determined it is not possible to calculate the volumes of extracellular water which were lost along with this sodium diuresis. However the sodium loss does point to a loss of extracellular water in volumes falling within the range we have described.

In assessing our measurements of extracellular water we would say that they seem to confirm the clinical impressions that (1) maternal hydration does occur in pregnancy and

(2) there is a rapid loss of the retained water in the puerperium. In addition, the measurements show (3) that most—if not all—of the water retained is extracellular, and (4) that most of the “normal” weight gain in pregnancy is accounted for by the conception product plus extracellular water.

Not all observers have agreed that hydration of the maternal tissues does occur in pregnancy. Freyberg, Reekie, and Folsome studied the water, sodium, and energy exchange during the latter part of pregnancy in a normal primigravida, and concluded that she had not retained more water than could be accounted for in her conception product. Also Beck, in his textbook, writes that most of the weight gain over and above that found in the conception product is attributable to maternal fat, he does concede that there may be some water retention however. Childs and Eichelberger, from analyses of muscle, found no indication of any increase in tissue water in the pregnant dog.

It is possible that the thiocyanate method for measuring extracellular water may give misleading results. Perhaps the cell permeability increases in late pregnancy, thus allowing the entry of the thiocyanate. If this should happen, then the apparent extracellular volume would include some intracellular water. However, if the thiocyanate ion enters such cells, it would seem that sodium and chloride ions might also do so, and the intracellular water included in the measurement would be *functionally* extracellular regardless of its location.

We prefer to accept the measurements of thiocyanate-available water at face value, for the increase during pregnancy and the recession postpartum are in accord with the clinical impressions which are mentioned in this study.

#### SUMMARY AND CONCLUSIONS

1 In a series of 16 normal patients, we have determined the changes occurring in the volume of thiocyanate-available water (extracellular water) during delivery and in the early and late puerperium. The puerperal water loss was measured in an additional series of 14 patients.

2 Incidental observations were made upon the distribution of thiocyanate as between maternal serum on one hand, and cord serum, amniotic fluid, placental tissue, and milk on the other.

3 The loss of available water at delivery averaged 1.74 liters, or 3.80 pounds. This can be accounted for in the fetus, placenta, amniotic fluid and maternal blood loss.

4 The major loss in available water usually occurred in the first 6 days postpartum. The average loss for this period was 2.30 liters, or 5.02 pounds.

5 The loss in available water between the 6th and 10th postpartum days was usually insignificant.

6 Between the 6th day and 6th week postpartum, all but 2 of 27 patients showed further losses in available water, often in the face of weight gains.

7 The total loss in available water, from just antepartum to 6 weeks postpartum, averaged 6.06 liters or 13.24 pounds in the 13 patients in whom the relevant measurements were made.

8 The total puerperal loss in available water, from just postpartum to 6 weeks later averaged 3.80 liters or 8.30 pounds in 27 patients. Presumably this quantity of water had contributed to the hydration of the maternal tissues during pregnancy.

9 The concentration of thiocyanate in cord serum averaged 90 per cent of that in maternal serum. The probable reason for this was discussed.

10 All of the placental water (making up 82.63 per cent of the placenta by weight) appeared to be available to thiocyanate. The concentration of thiocyanate in placental water averaged 92 per cent of that in maternal serum.

11 The concentration of thiocyanate in the amniotic fluid rose progressively toward the maternal serum concentration.

12 The concentration of thiocyanate in breast milk ranged from about 6 per cent to 52 per cent of the concentration in maternal serum. The concentration in milk taken before nursing was about the same as that taken after, apparently ruling out progressive passive diffusion of thiocyanate into the stored

milk. Equilibrium between maternal serum and milk was established within 4 hours.

13 It appears that most of the normal weight gain in pregnancy can be accounted for when the weight of the conception product and the weight of extracellular water gained in pregnancy (and lost in the puerperium) are added together. By "normal weight gain" we mean gains of 20 to 25 pounds in women who quickly return nearly to their prepregnancy weights.

#### REFERENCES

- BRICK, A. C. *Obstetrical Practice*. P. 28. Baltimore: Williams & Wilkins Co., 1930.
1. BR. P. V. *Am. J. Obst.*, 1933, 15, 802-809.
2. CHEESLEY, L. C. *Surg. Gyn. Obst.*, 1943, 76, 589-592.
3. Idem. *J. Biol. Chem.*, 1944, 140, 33-44.
4. CHEESLEY, L. C., and ALCOTT, J. E. *Am. J. Obst.*, 1943, 45, 66-67.
5. CHEESLEY, L. C., and CHEESLEY, E. R. *Am. J. Obst.*, 1944, 4, 976-983.
6. Idem. 1943, 45, 743-76.
7. CHILDS, A., and ECKSTEINER, L. *Am. J. Physiol.*, 1942, 37, 381-391.
8. CHASTICE, E. G. *Surg. Gyn. Obst.*, 1939, 68, 7-29.
9. CHAVALL, L. A., and AVDEYEV, M. Y. *Am. J. Digest. Dis.*, 1934, 36-43.
10. FLEISHER, L. B., and GILLMORE, A. *Am. J. Physiol.*, 1944, 36, 757-76.
11. F. EYBERG, R. H. REED, R. D., and FOLBORN, C. *Am. J. Obst.*, 1938, 36, 200-208.
12. L. VERTER, P. H., BOURDELLOV, J., and KUNZROFFER, K. A. *J. Clin. Invest.*, 1936, 5, 26-268.
13. OBERST, F. W., and PLASS, E. D. *Am. J. Obst.*, 1935, 3, 6-70.
14. ROBERTS, C. W., J. D., and L. VERTER, P. H. *J. Biol. Chem.*, 1930, 31, 665-674.
15. T. YLON, H. C., WARTNER, R. C., and WELSH, C. A. *Am. J. Obst.*, 1943, 45, 517-528.
16. W. TERN, E. G. *Am. J. Obst.*, 1944, 45, 826-832.

# THORACIC INJURIES

## Review of Cases

DANIEL C ELKIN, M D, F A C S, Lieutenant Colonel, M C, A U S, and  
FREDERICK W COOPER, Jr M D, 1st Lieutenant, M C, A U S, Atlanta, Georgia

IN the past wars thoracic injuries have been attended by high rates of mortality and morbidity. Prompt recognition of the seriousness of these wounds with restoration of normal cardiorespiratory physiology is essential because of the narrow margin of safety under which this system functions. In the last World War there were 4,595 cases of thoracic injuries among our casualties, with a mortality of 24.05 per cent (11). Duval collected a series of 3,453 cases of chest wounds in the last war by reports from 37 authors and found a general mortality of 20 per cent. Ransom, in quoting statistics for various wars since the Crimean has shown a progressively decreasing mortality rate in injuries of the chest. In the Crimean war the English lost 79.2 per cent, in the War between the States 62.6 per cent were lost, the Germans lost 56.7 per cent in the Franco-Prussian War, the British lost 27.5 per cent in the first World War, the Chinese have lost 14.8 per cent in the current Sino-Japanese conflict.

The principal considerations in the treatment of all chest injuries are, first, the treatment of shock, second, the restoration of normal cardiorespiratory physiology, and, third, the treatment of any complications or sequelae which may arise. It has been concluded that surgical intervention in the treatment of thoracic injuries is indicated in the presence of (1) open, sucking wounds of the chest, (2) stab wounds of the heart, (3) compression or tension pneumothorax, (4) extensive subcutaneous emphysema, (5) severe hemorrhage from intercostal or internal mammary vessels, (6) large, lacerated wounds of the lung, (7) wound infections, and (8) empyema. Other conditions which must be watched for and

treated as they arise are traumatic asphyxia, "blast injuries" to the lung, and paralytic ileus.

Thoracic injuries may be divided into (1) subcutaneous injuries and (2) open or penetrating wounds of the chest.

### SUBCUTANEOUS INJURIES

*Rib fractures* Extensive pleuropulmonary damage may be produced by single or multiple rib fractures if bone fragments are depressed. At times the thoracic cage may be so badly crushed that free motion of the chest wall occurs with each inspiration and expiration. In these cases, as in those with bilateral rib fractures, shock is usually present and the dynamics of the respiration are greatly impaired. With the addition of either a pneumothorax or hemothorax the outcome may be rapidly fatal.

Opiates should be given for the relief of pain, the chest should be splinted with adhesive or elastic dressings, and intercostal nerve blocks may be performed. Oxygen may be administered by the most convenient method at hand. If bony fragments are depressed and are resulting in pleuropulmonary damage, these will require elevation.

*Traumatic asphyxia* Traumatic asphyxia, produced by violent but temporary compression of the chest, may be manifested by two types of external physical findings: (1) pallor and (2) ecchymosis.

In the pale type, which is more serious, there is a pallor of the face and neck with a purplish discoloration. The pulse is fast and weak, respirations are short and irregular, the skin is cool, the patient may be unconscious. The treatment is that of shock and especially with the administration of oxygen.

The ecchymotic type results from the forcible ejection of the blood from the mediasti-



nal veins into the valveless veins of the head and neck. Subconjunctival hemorrhages, exophthalmos, and petechiae into the skin result. Treatment is supportive with the administration of oxygen where necessary.

**Blast injuries ("lung blast" pulmonary concussion)** Lung blast is produced by the sudden diffuse compression of the lung through the chest and abdominal walls as a result of the detonation of a high explosive. This hemorrhagic lesion of the lung is usually unaccompanied by any significant injury to the thoracic wall.

In the severe cases the diagnosis is not difficult. The symptoms are usually those of restlessness, dyspnea, chest pain, cyanosis, and shock out of proportion to the extent of the injury. The sputum may be blood stained or frank hemoptysis may occur. The chest wall is held in a position of partial inspiration with poor respiratory excursion. Impairment of the percussion note in one area with distant breath sounds in all fields and accompanying coarse moist râles may be demonstrated. In the less severe cases the diagnosis may be more difficult and can only be substantiated by characteristic x ray findings. The x ray findings resemble in some measure, those of patchy pneumonic consolidation (13).

Zuckerman, Hooker and Marinesco have shown experimentally that the outstanding lesion is hemorrhage into the lungs varying in degree according to the pressure to which the animals have been exposed. Osborn states that the actual lesion is mainly hemorrhage from alveolar capillaries with but little blood flowing into the bronchioles. The liberation of large quantities of mucus by ruptured goblet cells is indicative of severe damage. Subpleural "rib markings," more extensive injury in the phrenicocostal sinus, and deep and posterior lesions in the region of the hilus are indicative of a predisposition of certain parts of the lung to injury. The treatment is that of shock with liberal use of plasma. Morphine should be given with caution in the event that there has been accompanying intracranial damage. Oxygen may be administered when necessary. The sulfonamides are helpful in the prevention of pneumonia which frequently follows within 24 to 36 hours. The important

factor is to appreciate the pulmonary damage and to insist on bed rest for a period of at least 24 hours.

Tears in the liver and spleen are not infrequently produced by the abdominal compression. If in the treatment of other injuries, it becomes necessary to administer general anesthesia, intravenous sodium pentothal has been found to be least hazardous (16-17). Williams has recommended a light induction with sodium pentothal followed by a nitrous oxide oxygen anesthesia.

#### OPEN OR PENETRATING WOUNDS

Small penetrating wounds of the chest usually close spontaneously and are not of a "sucking" nature. However if the wound remains patent the injured individual will almost always seal the opening with his hand or with wadded clothing. The treatment in these conditions will vary with regard to the extent of the intrathoracic damage. It is usually sufficient to prepare the skin about the wound with an antiseptic, care being taken not to place irritating solutions upon the wound or to permit fluids to drain into the pleural cavity and to take a single suture through the skin, subcutaneous tissue and muscle down to the rib. This suture is tied only tightly enough to approximate the tissues over the pleural wound. The skin may further be closed with silk to secure more accurate approximation of the margins. Sulfanilamide may be dusted into the wound before closure if desired. To insure the cessation of leakage of air from the pleural cavity into the subcutaneous tissue, the application of a tight pressure dressing over the site of the pleural wound is imperative. Morphine is given for the relief of pain and apprehension and Fowler's position will facilitate respiration. The administration of oxygen is rarely a necessity in uncomplicated cases.

In open sucking wounds of the chest the lung will occasionally prolapse and, if rib fragments are present, laceration of the lung may result. Treatment will consist in debridement of the wound under positive pressure anesthesia with the lung held to prevent its premature return into the chest. The lung is cleansed and sutured and replaced in the

chest A layer closure of the wound is carried out If there has been extensive damage to the lung, drainage by water seal catheter should be done

**Hemorrhage** Hemorrhage from the thoracic wall is usually not severe Bleeding from the lung will usually be stopped when the lung is collapsed by the accumulating blood and when the rising intrapleural pressure becomes great enough to act as a tamponade Evidence of increasing blood loss into the pleural cavity with continued shock after closure of the wound and application of pressure demands immediate operative intervention The wound is explored under local anesthesia and any bleeding intercostal or internal mammary vessel is ligated Hemorrhage from the pulmonary structures, when severe, is usually rapidly fatal There are certain instances in which a prompt exploration of the chest will be necessary Débridement and suture of large lacerated wounds of the lung, or repair of injuries to the hilar structures is of necessity attendant with high mortality It is frequently difficult to ascertain which patients should be subjected to early radical surgery Readily available plasma and whole blood are invaluable in the management of these cases

Aspiration of blood from the chest is done only in those patients who show severe dyspnea or pain or in the small group who show no evidence of absorption of blood within 14 to

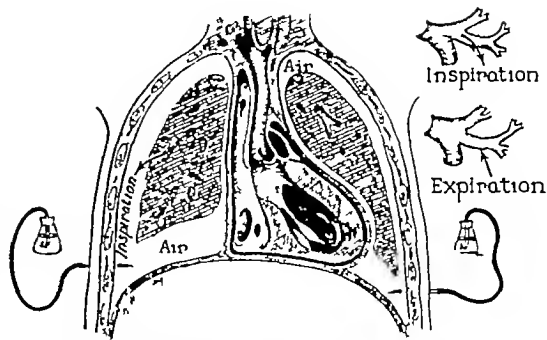


Fig 1 Apparatus for relief of tension pneumothorax Trapped air is released by water seal drainage

21 days after the accident It is usually advisable to replace the blood with an equal volume of air to prevent further bleeding from the injured lung or vessels if the injury is of less than 3 days' duration Since Morelli advocated the aspiration of all blood from the pleural cavity with air replacement during the World War I, this method of treatment has gained wide favor in England This view was recently expressed by Edwards before the Royal Society of Medicine However, in 1939 Foster sent questionnaires to leading surgeons in general hospitals throughout the United States obtaining data from 52 cities and in only 2 cities was aspiration and air injection the method of choice

**Pneumothorax** The presence of a large volume of air within the pleural cavity is readily



Fig 2 a, left, Extensive subcutaneous emphysema treated by layer closure of the wound with insertion of a needle for tension pneumothorax b, Same patient 5 days following treatment.



Fig. 3. a, left, Hemothorax produced by stab wound with knife. b, Roentgenogram 5 days later without aspiration.

tolerated if the pressure is not increasing. In general a conservative plan of treatment may be followed as the air is rapidly absorbed.

Not infrequently a valve-like tear of the lung or bronchioles may result which will allow the air to enter the pleural cavity with inspiration but prevents its escape with expiration as is illustrated in Figure 1. The tension or compression pneumothorax which results will be rapidly fatal if unrecognized. The best method of treatment consists in the insertion of a large caliber short needle into the pleural cavity in this manner the air is permitted to escape through a connected tube which has been submerged in a flask of water under the bed.

Bilateral pneumothorax, if marked may produce death due to the decreased vital capacity of the lungs. The air should be withdrawn by means of the method described, or simply with a needle and syringe. When the bilateral pneumothorax is slight and no distressing symptoms are present, aspiration is contraindicated.

**Emphysema.** With the escape of air from the normal respiratory channels in pleuropulmonary injuries, two types of emphysema may develop: (1) subcutaneous and (2) mediastinal.

Subcutaneous emphysema results from the forcing of air through a pleural rent into the subcutaneous tissue of the chest wall. Exten-

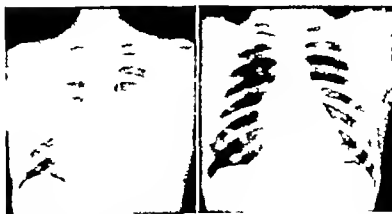


Fig. 4. a, left, Hemopneumothorax produced by stab wound with knife. b, Same case 20 days later without aspiration.



Fig 5 a, left, Hemothorax produced by stab wound with knife b, Roentgenogram of same patient 16 days later without aspiration



Fig 6 a, left, Hemopneumothorax produced by stab wound with knife b, Roentgenogram of same patient 15 days later without aspiration

sive crepitation may also be produced by a superficial wound in a muscular area if the patient has continued to contract these muscles with the resulting mechanical dispersion of air through the part. The presence of subcutaneous crepitation about a chest laceration is not therefore necessarily diagnostic of a penetrating wound of the chest. Extensive subcutaneous emphysema is not of serious consequence except for the discomfort and mental anguish to the patient. It is usually sufficient to close the wound carefully and apply pressure more accurately over the pleural tear which, in many cases, may be far distant from the actual site of the cutaneous wound. The patient must then be carefully watched for the development of a tension pneumothorax, for the emphysema may have been a "safety valve" for the accumulating air. Similarly, if extensive subcutaneous emphysema shows no evidence of rapid disappear-

ance after wound closure, a needle should be inserted into chest as in tension pneumothorax.

Mediastinal emphysema may result with escape of air along the peribronchial and perivascular tissue to the mediastinum. This type of emphysema may be of a serious nature if the tension is sufficiently great to interfere with the cardiorespiratory physiology. The symptoms are usually those of cardiopulmonary distress, and the diagnosis may be established by the demonstration of crepitation in the suprasternal notch, crepitation on auscultation over the sternum, or by the presence of mediastinal emphysema on x-ray examination. The treatment, if the condition is severe, consists in aspiration of air from the pleural cavity to relieve tension on the mediastinal structures, or incision in the suprasternal notch with application of suction by means of an inverted funnel sealed over the wound and connected to a source of suction.



Fig 7 a, left, Hemothorax produced by stab wound b, Roentgenogram of same patient 16 days later without aspiration



Fig. 8. a, left, Hemothorax and parenchymal hemorrhage produced by stab wound with kulla. b, Roentgenogram of same patient 9 days later without aspiration.

*Penetrating wounds of the heart* Penetrating wounds of the heart have not been included in this series, but this type of injury may be produced by stab bullet or freak accidents. The symptoms are those of cardiac tamponade produced by the accumulation of blood within the pericardial sac and may vary markedly. Collapse unconsciousness fecal incontinence feeble pulse distended neck veins, profuse perspiration and low or imperceptible blood pressure are frequent findings. The venous pressure is usually but not invariably elevated and may be as high as 340 millimeters of water. The most valuable single examination is the fluoroscopic visualization of the heart. The absence of visible pulsations is diagnostic of the condition. If the heart is examined and found to pulsate well, and a

short while later the pulsations show more diminution in volume but are still present the heart should be explored if the other physical findings are compatible with a diagnosis of penetrating wound of the heart. Many of these patients appear moribund and one is frequently tempted to aspirate the pericardium. However it should be remembered that only those survive to reach the hospital and surgery who have sufficient blocking of the pericardial wound by the surrounding structures to prevent the escape of blood, thus preventing exsanguination and producing a cardiac tamponade. The tamponade in reality produces a useful function in that when the pressure becomes sufficiently high escape of blood from the heart is prevented and the heart is able to continue to function although



Fig. 9. a, left, Parenchymal hemorrhage due to multiple stab wounds with ice pack. b, Roentgenogram of same patient 26 days later.



Fig 10 a, left, Parenchymal hemorrhage due to multiple stab wounds with ice pick. b, Roentgenogram of same patient 9 days later

the cardiac output is greatly diminished. At operation as the pericardium is rapidly opened and the pericardial contents quickly evacuated, the heart wound will frequently be seen to be temporarily sealed, only to start spurting shortly after the tamponade is removed and the intracardiac pressure again rises with unrestricted cardiac contraction.

Immediate surgery offers the patient the only chance for survival. The quickest and most satisfactory approach is through a transverse incision, with removal of one or more cartilages and a portion of the sternum. The intercostal and internal mammary vessels are ligated. The pleura is dissected laterally by blunt gauze dissection. The pericardium is opened and the contents evacuated. Silk sutures are placed in the heart wound which may be covered by a finger until the suture can be taken. The pericardium and wound are then closed in layers with black silk.

#### REVIEW OF CASES

Wounds of the chest occurring in civilian practice differ from those incurred in warfare in that they are less extensive and are not associated with the same degree of contamination from foreign bodies, dirt, rib fragments, and clothing carried into the chest by the missiles.

During the past 8 years 1,132 penetrating wounds of the chest have been admitted to the Emory Division of Grady Hospital. The mor-

tality rate in this group was 63.6 per cent. Of this number 117 were gunshot wounds while the remaining were produced by knives or ice picks. The most frequent injury was one produced by a so called "switch blade" knife, this weapon having a narrow blade approximately 4 inches long. The ice pick usually produces a hemopneumothorax, but not infrequently the picture is one of parenchymal hemorrhage. During the past 2 years 418 cases have been treated with a mortality of 33 per cent. In the former group the incidence of empyema was 17.6 per cent.

One hundred consecutive cases of penetrating wounds of the chest have been carefully followed by frequent roentgenograms and physical examinations over a period of 1 year. In this group were 86 knife wounds, 9 from ice picks, and 5 gunshot wounds. Hemoptysis was noted in 14 per cent, subcutaneous crepitation in 82 per cent, and sucking wounds in 16 per cent. Patients with stab wounds of the heart or with associated intra-abdominal injury have been omitted from this series. During this period 2 fatalities occurred, with both patients dying within a short time after admission. It was thought that death was due to hemorrhage from large pulmonary vessels. Autopsies were not obtained in either case.

The venous pressure was found to vary from 110-300 millimeters of water, averaging 174 millimeters of water. The pressure was meas-

ured with the patient lying flat with manometer on a level with the skin of the back. In contrast to the common finding of incontinence of feces and urine in patients with stab wounds of the heart, only 2 of this group were thus affected.

X-ray examination revealed a pure hemothorax in 38 per cent, a pneumothorax in 18 per cent and a combined hemopneumothorax in 35 per cent. Parenchymal hemorrhage was present in 9 cases, 7 of these cases being in multiple ice pick stab wounds of the chest.

### RESULTS

Eighty nine per cent of the patients showed no x ray evidence of pulmonary lesions within 5 to 29 days. There was no residual pleural thickening. The average time required for absorption of the blood and air was 17 days in this group.

Nine patients showed evidence of delayed absorption of blood and 8 of these cases were aspirated with replacement of the fluid removed with air. The process then cleared completely within from 35 days to 5 months. The 5 month period for resolution of pleural thickening was required in a patient who developed numerous encapsulated pockets of fluid. In this group 2 patients developed empyema which was treated by thoracotomy and rib resection.

### SUMMARY AND CONCLUSIONS

1 The principal considerations in the treatment of all chest injuries are (a) the restoration of normal cardiorespiratory physiology (b) the treatment of shock and (c) the treatment of any complications or sequelae which may arise.

2 A total of 1132 cases of penetrating wounds of the chest is presented with a mortality of 6.36 per cent and with a 1.76 per cent incidence of empyema.

3 The treatment of chest injuries is in general conservative and nonoperative.

4 Aspiration of blood with air replacement is indicated in case of dyspnea, severe pain, or delayed absorption of blood.

5 In a group of 100 consecutive patients 89 per cent showed no x-ray evidence of pulmonary lesions after 29 days (average 17 days); 98 per cent had no evidence of pleural thickening at the end of 5 months.

### REFERENCES

1. DEVAL, P. Les plaies de guerre du pomeau. Paris: Masson et Cie, 97.
2. LOWYER, A. T. *Proc. R. Soc. M., Lond.* 940, 34, 80.
3. ELERY, D. C. *South. M. J.* 615, 23, 4.
4. *Idem* *J. Am. M. Ass.*, 936, 7, 8-154.
5. *Idem* *Surg. Clin. N. America*, 612, 1975.
6. ELERY, D. C. and HARRIS, M. H. *Am. Surg.* 94, 683-694.
7. ELERY, D. C. and S. VASSOK, J. C. *J. Thorac. Surg.* 933, 433.
8. FOOTER, J. M. *J. T. Writ. Surg. Ass.* 936, 45, 476.
9. HOOKER, D. E. *Am. J. Physiol.* 924, 87, 9.
10. MANTON, G. *Rev. Med. Par.* 9, 2, 51, 279.
11. Medical and Casualty Statistics, Part II. The Medical Department of the United States Army in the World War, 1922. Washington, D. C. Government Printing Office, 97.
12. MORRILL, E. The Treatment of Wounds of the Lungs and Pleura. Translated by Lincoln Davis and Frederick C. Irving. Boston: W. M. Leonard, 1920.
13. O'REILL, J. N. Glover, S. R. *Lancet*, Lond. 1944, 4, 3.
14. OSMON, G. R. *Brit. M. J.* 944, 506.
15. RANKIN, F. T. *J. Thorac. Surg.* 940, 9, 178.
16. ROBERTS, J. E., and TURNER, O. S. *Am. J. Surg.* 94, 54, 259.
17. ROSE, T. F. *M. J. Australia*, 942, 784.
18. WILLIAMS, E. R. P. *Brit. J. Surg.* 942, 90, 34.
19. ZUCKERMAN, S. *Proc. R. Soc. M. Lond.* 94, 34.

# CYSTOSARCOMA PHYLLOIDES

## With a Consideration of Its More Malignant Variant

WILLIAM GRANT COOPER, Jr, M D, and LAUREN V ACKERMAN, M D,  
Columbia, Missouri

**T**HIS paper reports 3 cases of cystosarcoma phylloides of the female breast, one of which has metastasized to the axillary lymph nodes. In searching the literature, we have failed to find any case similarly illustrated with photomicrographs.

Cystosarcoma phylloides is the most common of scores of names used for this tumor. We therefore retain it with the following definition. It is a tumor arising from the connective tissue of a pre-existing mammary adenofibroma. The clinical history usually obtained is that the patient in her fourth or fifth decade has been aware of a quiescent, small, hard breast nodule for many years with later growth to a huge size without associated constitutional symptoms. On examination, the breast is found tremendously enlarged and characteristically ovoid in shape. The overlying skin and nipple are not invaded, although local extension may have taken place to the adjacent structures. Regional lymphadenopathy is not evident unless infection is superimposed. Grossly, the tumor is found to contain frond-like pleats resembling a head of cauliflower, from which appearance it takes its name. Microscopically, the unique finding is the increase in the fibrous elements. The associated metaplastic changes, areas of ectopic cartilage or bone, and the acinar proliferation which sometimes occur are not of definitive value. "Atypical carcinoma," lymphosarcoma, and diffuse fibrosarcoma of the breast must be rigidly excluded from this group. These patients usually do well when treated by wide local excision, and the prognosis in general is good.

Although Sir Ashley Cooper and Brodie mentioned this tumor, Johannes Mueller, in

1838, gave a classical description of several cases, calling them cystosarcoma phylloides and clearly separating this from the general group of breast lesions. Velpeau and others have reported patients with enormous mammae weighing up to 40 pounds. Axillary lymph node involvement is but rarely noted, and then mention is made of complicating factors which raise the possibility that the enlargement is due either to extraneous causes or is of an unproved nature. For instance, in the 16 cases reviewed by Rose, none had lymph node involvement. Boldrey listed 4 cases of fibrosarcoma, of which one had enlarged lymph nodes, but it is stated that they were "due to tuberculous infection." Williams in 24 cases had 2 in which lymph gland dissemination had occurred. Both of these were of the "round cell variety of the disease" and possibly represented lymphosarcoma. In other instances, clinical mention was made of palpable (i.e. enlarged) lymph nodes, but microscopic examination or photographic evidence or both was not given. Hill and Stout suggest that "metastasis to the axilla probably never occurred." Growth during pregnancy is infrequent, but increase in size during the menopause has been noted occasionally. As the age group of these patients extends through the years of the climacteric, the association of growth with the menopause may be but coincidental. Many writers emphasize the generally benign course of cystosarcoma phylloides (7), and there are examples of 5 year arrests following local excision, yet not all cases of cystosarcoma phylloides run this benign course. An occasional instance of pulmonary (4), osseous (11) or extensive local spread with eventual fatality is mentioned. One remarkable case of a persistent surgeon and submissive patient was recorded by Hoffman wherein 12 recurrences occurred and 12 operations were

From the Surgical and the Pathological Departments of the Ellis Fischel State Cancer Hospital, Columbia, Missouri





Fig. 1. Case 1. Note ulceration android like projection.

performed. A 4 year period of freedom from disease ensued only to be followed by eventual death from metastases. In discussing a malignant variant of cystosarcoma phyllodes White reported a case with "autopsy showing extensive growth on the chest at the site of removal of the left breast metastases in the right breast in the anterior mediastinum and in the lungs." Excellent reviews of the subject are available (5, 7).

The following is a brief summary of our 3 cases. Two of them represent the benign and one the malignant variant of this disease.

**CASE 1** O. EFSCHN 45, a 57 year old white American housewife had a 3 to 4 centimeter movable nodule in the left breast for 3 years with slow growth until 5 months prior to admission, when it enlarged to mass by 20 centimeters in size. Examination here (Figs. 1, 2) showed a large mass replacing the left breast (Fig. 1). The tumor was ulcerated through the skin in one area and on the same side 3 axillary lymph nodes measuring centimeters in diameter were palpable. It was our



Fig. 2. Case 1. Photomicrograph demonstrating intracanalicular appearance of the tumor with marked problem of the connective tissue. Hematoxylin and eosin  $\times 35$ .

opinion that the lymphadenopathy was associated not with metastatic disease in the nodes, but with inflammatory response to the superimposed infection. Complete skeletal series was negative for evidence of pulmonary or osseous metastases. A simple mastectomy was done on June 30. The subsequent course (9 months) has been eventful. The gross specimen weighed 1,041 grams and contained a large tumor mass which had fungated through the skin. It was made up of round sized nodules with clefts and lacunae between them. Microscopically early connective tissue proliferation of the intracanalicular type was seen (Fig. 3).

This case presents a typical picture of cystosarcoma phyllodes. The patient was in her sixth decade and the breast fibroma was known to have been present in the quiescent stage for 1½ years before rapid growth began. No cause for the onset of proliferation can be given. The menopause had occurred some 10 years before. The aforementioned lymphadenopathy disappeared with the removal of the inflammatory lesion and the prognosis from wide local excision alone should be excellent.



Fig 3 Case 2 The breast is drop shaped, and the nipple has been flattened

CASE 2 C W, EFSCH No 3958, a 75 year old white American housewife, had a 3 centimeter nodule present in the upper and outer quadrant of the right breast without increase in size for 10 years. Six months prior to admission (April 6, 1942) rapid growth began. Examination revealed a 15 by 15 centimeter, drop shaped mass in the breast without skin or muscle fixation (Fig 3). No lymphadenopathy was present. Skeletal series was negative for evidence of pulmonary or osseous metastases. On April 8, a simple mastectomy was done. The gross



Fig 4. Case 3 Tumor recurrence growing in the region of the previous operation

specimen weighed 1,130 grams and was similar in appearance to that of the first case except that skin ulceration had not occurred. Microscopically, proliferation of connective tissue with an occasional area of myxoma-like stroma was present. Evidence of the tumor's origin from an adenofibroma could again be demonstrated.



Fig 5a



Fig 5b



Fig 5 Case 3 Observe tumor just beneath the skin and its gelatinous and hemorrhagic appearance a, above, First recurrence, b, third recurrence, c, fifth recurrence

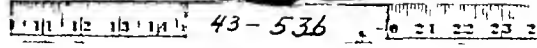


Fig 5c



Fig 6 Case 1. Net tumor growing just beneath the skin. Cellularity is increased, and there are areas of myxomatous change in the stroma. Hematoxylin and eosin,  $\times 20$ .

This patient also represents the usual picture of cystosarcoma phyllodes, with the exception of her advanced age. In patients aged 75 most massive breast tumors are carcinomas and cystosarcoma phyllodes is seldom considered in the differential diagnosis. Her postoperative course (11 months) has been uneventful, and no evidence of local or distant recurrence was found at her last clinic visit.

**CASE 3.** C. G. ETSCH No. 434, a 53-year-old white American housewife had a 1-centimeter movable nodule just lateral to the nipple of the left breast for 2 years. Three years prior to admission, it began to grow until 3 months before being seen here part of the tumor weighing 1,750 grams was removed by her family physician. Eight months later recurrence was evident in the scar. She was referred to us, but admission was not sought for 3 months. Examination then, April 26, 1942, showed nodular tender mass 5 centimeters in diameter protruding from the excision scar in the left breast (Fig. 4). The ipsilateral axillary lymph nodes were not palpable. Complete skeletal series was negative for evidence of pulmonary or osseous metastases. A left radical mastectomy with split graft was done on April 29. Her immediate postoperative course was uneventful but a second recurrence was noted 6 months later. At removal, on October 16, tumor was found on the chest wall overlying the 7th rib (the midclavicular line). A third recurrence was noted in 3 months, and at operation on January 23, 1943, tumor was found penetrating the chest wall anteriorly and a second mass burrowing between the thoracic wall and the scapula. These were removed. X-ray later showed

"possible pleural metastases adjacent to the rib, from which the recurrence had been removed. Grossly the specimen removed before admission showed nodular soft tumor tissue beneath an intact skin. It was made up of numerous nodules and intricate clefts. On section, it was grayish-white with multiple areas of hemorrhage and some gelatinous zones. Tumor extended to the limits of excision. The subsequent specimens were similar in appearance except that areas of hemorrhage and gelatinous change were more prominent, and that from the radical mastectomy showed invasion of muscle and enlargement of three lymph nodes (Figs. 5, 6, 7). Microscopical sections showed interlacing bands of connective tissue. The nuclei were spindle-shaped and fairly uniform in size. There were however fairly numerous mitotic figures present with occasional areas showing marked variation in cell size. These areas of fibrous anaplasia were patchy in distribution, alternating with fields in which tumor was of the usual innocent appearance. The myxomatous zones showed fairly marked cellularity and resembled the embryonal type of connective tissue. Phosphotungstic acid stains demonstrated numerous fibroglia fibers. Muscle invasion was evident, and 3 of 14 lymph nodes examined were completely replaced by tumor tissue of the same characteristics as that described in the primary breast lesion.

This case although as assuredly one of cystosarcoma as the others has run a different and more malignant course. The original

"The finding of lymph node metastases, although unexpected, and incredible, is possible because of the mode of spread usually seen in fibrosarcoma arising at other locations."



Fig 7 Case 3. This axillary lymph node is completely replaced by tumor. Hematoxylin and eosin,  $\times 64$ .

breast nodule was present for 9 years without increase in size and for 3 years more with very slow growth. A first removal was followed by local recurrence in 10 months, a second and more radical removal by recurrence in 6 months, and a third and fourth by wider and still more extensive recurrence in 3 and 2 months, respectively. There was no association of pregnancy or the menopause with this increased rate of growth. Clinically, it and the other cases previously cited in the literature (12, 13) which also ran a rapidly malignant course, differ from the usual case of cystosarcoma phylloides by certain specific particulars, viz the history is notable because of either rapid growth or swift recurrence. Examination of the patient is noncontributory but fixation of the mass to underlying tissue, if present, would demonstrate muscle invasion. The presence or absence of palpable axillary lymph nodes is not of significance either as to their involvement in, or freedom from, metastatic disease. Most important, the fresh operating room specimen is softer and shows lobules which are less clearly outlined than those of the classical cystosarcoma phylloides. The surface is mucoid, without the dry and definite appearance of the more benign lesion. Areas of fleshy tint with gelatinous zones and dark blue blotches of glairy hemorrhage suggest its more dangerous nature. Muscle involvement, if demonstrable, makes this unequivocal. A frozen section obtained at operation, coupled with this gross appearance, should help lead to the correct diagnostic conclusion. In order to avoid spillage of tumor cells, extreme care must be used in obtaining the material for frozen section.

#### SUMMARY

Cystosarcoma phylloides is an interesting and not too uncommon sarcoma of the breast, about 125 cases having been reported. Treatment by wide local excision is usually satisfactory. The use of x-ray therapy is probably not indicated. There occurs, however, marked variation in the lethal potentialities of these growths. In our first and second cases the

tumor was relatively benign, and in lesions of this, the usual type of cystosarcoma phylloides, a simple mastectomy suffices. Our third example stands at the other end of the scale and in its behavior resembles fibrosarcomas arising in other sites. In variants of such a degree of malignant tumor, the principal reliance of the surgeon for cure must be placed in an extremely wide local excision of the breast and surrounding structures. Muscle involvement, when present, makes removal of the pectoralis major and minor obligatory, and we now feel that, once these muscles have been removed, an axillary dissection should be done, intelligent exceptions to this being made when justified in a particular case.

From a presentation of 3 patients with cystosarcoma phylloides seen personally and from the experience of others as seen in the literature, it is suggested that cystosarcoma of the breast is, like all neoplasms, one whose potentialities vary from that of a very benign to that of a very malignant lesion. Our third case with invasion of muscle, metastases to axillary lymph nodes, and frequent recurrences represents the most malignant type. This variant requires a classical radical mastectomy with axillary dissection for cure.

#### REFERENCES

- 1 BOLDREY, E. B. *Canad. M. Ass. J.*, 1936, 35, 16.
- 2 BRODIE, B. C. *Lectures on Various Subjects in Pathology and Surgery*. P. 148. London: Longmans, Green & Co., 1846.
- 3 COOPER, SIR ASHLEY. *Illustrations of the Diseases of the Breast*. Part I, Pp. 32-45. London: Longmans, Green & Co., 1929.
- 4 GRAVES, T. C. *Brit. M. J.*, 1920, 1, 81.
- 5 HILL, R. P., and STOUT, A. P. *Arch. Surg.*, 1942, 44, 723.
- 6 HOFFMAN, A. *Arch. klin. Chir.*, 1894, 48, 93.
- 7 LEE, BURTON J., and PACK, GEORGE T. *Ann. Surg.*, 1931, 93, 250.
- 8 MUELLER, J. *Ueber den feinem Bau und die Formen der krankhaften Geschwulste*, p. 56. Berlin: G. Reimer, 1838.
- 9 ROSE, J. *Deut. Zschr. Chir.*, 1936, 246, 151.
- 10 VELPEAU, A. *Traite des Maladies du Sein et de la Region Mammaire*, p. 338. Paris: V. Masson, 1854.
- 11 WARRIN, SHIELDS, and MEYER, R. W. *Am. J. Path.*, 1938, 24, 605.
- 12 WHITE, J. W. *Am. J. Cancer*, 1940, 40, 458.
- 13 WILLIAMS, W. ROGER. *Diseases of the Breast*, p. 417. London: John Bale & Sons, 1894.

# RADIODERMATITIS OF THE HEAD AND NECK WITH A DISCUSSION OF ITS SURGICAL TREATMENT

FREDERICK A FIGI M.D. F.A.C.S., and GORDON B NEW M.D. F.A.C.S. and  
CHRISTOPHER R. DIX, M.D. Rochester, Minnesota

SERIOUS results may follow either inadequately controlled radium and roentgen therapy or the injudicious use of roentgen rays for diagnostic purposes. Radiodermatitis often has resulted from procedures carried out by inexperienced practitioners and by lay operators, but it may occur even in the hands of competent radiologists and at times with comparatively small doses. The hazards incident to the use of radium and roentgen rays have been known to the medical profession for many years and, as a result of prophylactic measures now generally carried out, the incidence of such lesions is decreasing.

The condition often produces severe disability and marked deformity, but its tendency to undergo malignant change is of even greater seriousness. While conservative measures are indicated for the treatment of the acute stages of the process and for mild chronic lesions, actual removal of the affected tissue affords the only means of relief when secondary irradiation changes are pronounced.

Chronic radiodermatitis is encountered fairly frequently. It occurs more often following roentgen therapy than after radium treatment and the former is usually of greater seriousness because of the more extensive area involved. The total dose given and the various factors concerned with its administration are chiefly responsible for these serious cutaneous changes but the tendency to induce such a reaction often is increased by rays from other sources, such as sunlight and ultra-violet and infra-red irradiation, and too by chronic irritation of other types. Moreover it has been observed that the skin of certain persons is unduly sensitive to irradiation either because of lack of normal pigment or because of an idiosyncrasy. Excessive reaction is observed particularly among those who have fair or ruddy complexion, red hair or a thin, dry skin. A single roentgen diagnostic procedure or one application of radiotherapy has produced at times extensive burns and necrosis among such patients. Men and women appear to be about equally affected. The condition occurs more frequently about the

head and neck than in other portions of the body probably because of the greater number of irradiation exposures made to these surfaces, rather than because of any possible difference in the susceptibility of the skin of these parts.

In a number of cases the most severe manifestations of radiodermatitis have followed irradiation used for comparatively minor conditions such as acne, eczema, psoriasis, pruritus and, hypertrichosis, warts, and other dermatological lesions. Many of the patients who had marked secondary radium and roentgen ray changes about the head and neck coming under our observation had received treatment for tuberculous cervical adenitis, actinomycosis, goiter and various skin conditions. In a few instances treatment for deep-seated neoplasms had been responsible for the changes. In these cases as in those resulting from treatment of malignant lesions of the skin the physician at least has the satisfaction of knowing that the condition induced usually is less serious than that for which treatment was given. This is decidedly in contrast to the sense of consternation and dismay caused by realization that treatment of a benign process has brought about pathological changes that not only are painful and disabling but bear the possibility of cancerous degeneration.

Some of the most extensive lesions that we have encountered resulted from the use of roentgen therapy by operators of beauty shops for depilatory purposes. In some instances the condition was induced by repeated applications of radium and roentgen rays to angiomas, especially of the port wine stain type, a lesion that is notoriously radioresistant and that physicians generally agree should not be subjected to intensive irradiation.

In a considerable proportion of the reported series of cases of radiodermatitis the patient is a physician, dentist, or a radium or roentgen ray technician who has been exposed to the rays while carrying on his professional duties. In a group of 39 cases of this condition reported by Saunders and Montgomery physicians and dentists comprised 10 per cent of the patients, and in Codman's series they made up 30 per cent. 1 of element of the hands is present among most of these patients.

Since the lesions under consideration in our paper are limited to the head and neck, no professional workers are included in the group except for a few who had received irradiation for lesions in this region. In a group of 55 physicians who had radiodermatitis and whose cases were reported by Leddy none had involvement of the face.

Insufficient protection and lack of appreciation of the serious possibilities of improperly controlled irradiation have been largely responsible for the majority of these injuries. It seems likely that better equipment, refinements of technique, and increased experience will greatly lessen the incidence of the condition in the future. However, in view of the present wide use of roentgen therapy in fractional doses and the severe acute reaction induced in most of these cases, one cannot but wonder whether serious secondary changes will not develop later in a large proportion of cases. Regardless of this possibility, the results obtained well justify this type of treatment, for without it most of these patients face a hopeless outlook.

Radiodermatitis may occur either as an acute process reaching its height within a few weeks following exposure to the rays or as a chronic condition becoming manifest only after the lapse of months or years. Depending on the dose, the screening, and the sensitivity of the patient's skin, the immediate or acute reaction may be so mild as to be scarcely evident clinically. On the other hand, the condition may present vesiculation, necrosis, and sloughing of varying extent accompanied by severe secondary infection and intense pain. The acute form is comparable to the three stages of burns except that the process progresses much more slowly. A dusky blue erythema is noted at the end of 2 weeks and either exuding or dry dermatitis after 3 weeks. A permanent brown discoloration due to increase of melanin and temporary or permanent loss of hair may follow this. At times when the acute reaction has been severe, complete loss of pigment results later.

The necrosis, sloughing, and secondary infection of this stage often produce protracted disability, for healing occurs only after many weeks or months. The most destructive effect of the irradiation occurs in a central area and gradually decreases toward the periphery of the exposed surface. The inflammatory and circulatory changes resulting from this gradation taper off so imperceptibly that it is impossible to recognize a definite line of demarcation between the devitalized and the healthy tissue. Months after the delayed healing the central portion of the area may break down again and the prolonged, painful

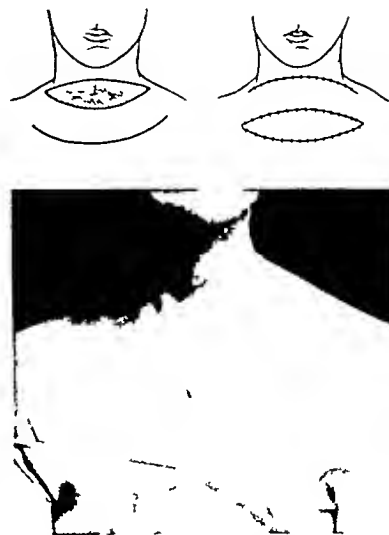


Fig 1 a, above, Plan of removal of actinodermatitis at base of neck anteriorly and immediate repair by means of double pedicle flap, a skin graft being applied to the donor site, b, result 4 months following operation

sloughing and ulceration recur. We have seen this process repeated several times during the course of a number of years following treatment of an extensive carcinoma on the base of the tongue. At the time of the acute flare-ups of the condition it was impossible to determine whether the process was inflammatory or a recurrence of the neoplasm. Unless the acute reaction has been very mild some permanent changes of the skin remain following its subsidence. Often these are scarcely discernible immediately after clearing of the acute process but become increasingly manifest during the course of a few months or at times only after the lapse of several years. Ulcers appearing during the reaction immediately following irradiation may persist as such but, more commonly, lesions of this type encountered in chronic radiodermatitis occur later as the result of secondary changes.

Chronic radiodermatitis is usually preceded by the acute form, a latent period of from 1 to 10 years generally intervening. It may result from repeated small exposures. In none of Leddy's series of 55 cases of such lesions occurring among physicians did the condition develop without there being obvious cutaneous changes present during the interim. Marked circulatory changes, dryness, fissuring, telangiectasia and atrophy of the cutaneous surface with disappearance of the sweat and sebaceous glands and hair follicles take place, giving the skin a smooth, dry, glistening appearance. Keratoses, sclerosis, and induration



Fig. 2. a, left, Actinomycetosis resulting from treatment of herpesigo 36 years previously; b, result following excision and repair with thin skin grafts. It had been planned to recover the area later with full thickness grafts but the appearance improved to such an extent that the patient decided to have nothing further done.

develop later and the skin becomes thick, leathery and immobile. Necrosis, sloughing and ulceration develop as a result of the atrophy of the skin and obliteration of its vascular supply. The ulcers vary from superficial lesions to deep craters that have thick, indurated edges and a necrotic base and may be fixed to the underlying structures. Fat is frequently exposed, cartilage, tendon, and muscle become exposed and perforation into the mouth, nose, larynx, and trachea at times occurs. The ulcers are extremely indolent and show little or no tendency to heal. Crusting due to the exudate from the ulcer is usually present and secondary infection with attendant pocketing of purulent material takes place. Intensive pruritus and severe, constant pain are complained of and are difficult to control. A complicating factor associated with the pruritus is the trauma produced by scratching.

Malignant changes often develop in the keratosis and persistent ulcers. The resulting epitheliomas usually are of squamous cell type. Their incidence in cases of radiodermatitis varies with the severity of the primary irradiation injury and the stage in which the cases are studied. Malignant lesions developed in 10 per cent of the group of 259 such cases reported by Saunders and Montgomery. However when only patients who had the more severe irradiation changes were considered, the proportion increased to 50 per cent. A long latent period almost invariably inter-

venes between the time of the initial exposure and the appearance of epitheliomatous change. This may be of only a few months' duration but more frequently it is at least several years in length and often it is more than a decade.

The activity of malignant lesions developing on this basis may range from 1 to 4, according to Broders' classification. The majority of them are of moderate activity or of low grade but fulminating malignant lesions may be present. In general because of the surrounding scleroses, even the highly malignant neoplasms among these are less likely to metastasize than other neoplasms of similar activity. Thus treatment carried out reasonably promptly after appearance of the malignant process should offer a satisfactory prognosis.

Because of the scleroses and ulceration, contractures often are present but because of the absence of keloids, contractures occur less commonly in cases of radiodermatitis than after the usual burns due to heat or caustic. The degree of deformity depends on the situation, extent and severity of the involvement. It may be marked about the eyelids, lips, and nostrils, especially if extensive ulceration is present or malignant change has supervened, and may constitute one of the most serious features of the condition.

#### PATHOLOGY

The histopathological characteristics of radiodermatitis have been shown to be the same



Fig 3a



Fig 3b



Fig 3c

following roentgen and radium applications. Studies of these lesions in man and in experimental animals were made by Wolbach, who noted (1) complete loss of the appendages of the skin as evidenced by the destruction of hair follicles and of sebaceous and sweat glands, (2) the replacement of normal collagen by a peculiar dense hyaline collagen rich in apparently new formed elastic and quite cellular tissue, (3) obliteration of the small vessels in the corium of the skin and subcutaneous tissues, the larger vessels showing varying degrees of thickening of the adventitia and media, and proliferation of the intima, (4) necrosis and rarefaction in the corium just under the epidermis, which usually were associated with thrombosed regions of telangiectasia, (5) reparative proliferation with hypertrophy of the epidermis.

#### TREATMENT

During the acute stage of actinodermatitis the results of operative procedures are likely to be disappointing, since it is difficult to determine the extent of the process. Only the tissues most seriously affected tend to slough, but unless these are removed completely, further necrosis will occur. In general, provided that damage to the tissue has not been unusually severe, the acute reaction is self-limiting and runs its course in a few weeks or months regardless of therapeutic measures instituted. During this period considerable palliation can be afforded by applications of a drying lotion or soothing ointments and by measures directed at combating the infection and acute inflammatory reaction, such as painting the sloughing area with a solution of acriflavine and

Fig 3 a and b, Radiodermatitis resulting from treatment of capillary angioma 7 years previously, c and d, result following excision and full thickness skin graft.



Fig 3d

gentian violet, dusting it freely with sulfathiazole powder and the use of warm, moist compresses. Radical measures are contraindicated at this time, for in the presence of the exudation, infection, and sloughing, they are likely to aggravate the condition and prolong the period of disability and pain.

The treatment indicated in cases of chronic radiodermatitis depends on the severity and extent of the changes, on whether epithelioma is present and on the age and general condition of the patient. Various types of dermatological treatment may keep the patient who has this condition reasonably comfortable provided that secondary changes are not advanced. However,





Fig. 4 a, left, Radiation dermatitis resulting from treatment of angioneuroma 5 years previously; b, result following excision and full thickness skin graft.

when sclerosis, atrophy and hyperkeratosis are pronounced and ulceration is present, only surgical treatment is likely to afford relief. If malignant change has developed, surgical removal is imperative.

The surgical treatment of chronic radiodermatitis consists of two parts: (1) removal of the diseased tissues and (2) repair of the resultant defect. In general these two stages are combined as a single operative procedure and it usually is decidedly advantageous to do so. However when there is considerable infection or necrosis present and when malignant change has taken place and

is advanced, it is sometimes advisable to remove the involved tissue widely, leave the wound open, and repair the defect at a later stage. This is especially true in cases of extensive or high grade malignant lesions and particularly if the tumor is fixed to the underlying bone or is so situated that only limited removal of tissue is possible. Delaying repair for some months in these cases allows the wound to heal over and the tissue to scar down. This may render it more difficult to secure a satisfactory cosmetic result but the open wound permits of closer scrutiny for possible recurrence of the neoplasm and the prognosis is greatly improved.



Fig. 5 a, left, Extensive epithelioma (basal cell and squamous cell, grade 2) developing in radiodermatitis following treatment of tuberculous adenitis in adolescence; b, result following tuberculous excision and immediate application of dermatomic graft of moderate thickness.



Fig 6 a and b, Radium dermatitis of both sides of neck resulting from treatment of extensive squamous cell epithelioma (grade 4) of nasopharynx with bilateral cervical metastasis 12 years previously, c and d, result following excision and full thickness skin grafts.

At times a lesion that has appeared clinically to be malignant will be found on microscopic examination following excision to be only a benign hyperplastic process but as this condition is potentially malignant, the removal of the tissue for prophylactic purposes is advisable. Fairly frequently, too, fixation in these cases is found at operation to be due to the extensive sclerosis and infiltration rather than to the presence of a neoplasm that has become attached to the underlying bony structures or is invading them. Such operative findings may permit of immediate repair when this had not been anticipated before operation. Fresh frozen sections, which afford the opportunity of immediate microscopic study, are decidedly advantageous in these cases since the report of the pathologist can be obtained within a very few minutes and while the operation is still in progress. The surgeon then is able to deal with the condition much more rationally than when he must rely entirely on the gross appear-

ance of the lesion. Accurate information concerning the histopathological characteristics and the limits of any malignant change that may be present is of the utmost value in determining the width of removal advisable and whether immediate plastic repair is justifiable.

Excision of a region of radiodermatitis serves several purposes. Primarily it removes the pathological process, and the removal in most cases affords immediate relief from the distressing symptoms whether the wound is closed immediately or is left open. It relaxes any contracture that may be present, permits histological study for possible malignant change and prepares a graft bed with an improved blood supply. The subsequent repair properly done furnishes an approximately normal integument, thereby improving the patient's appearance and restoring function.

As a rule little difficulty is experienced in determining the essential width of removal of such



b

FIG. 7 a. External epithelioma developing in radio-dermatitis resulting from treatment for capillary hemangioma of port. b. excision and immediate transfer of previously prepared lat pedicle flap from arm.

The donor sit on the arm as covered with full thickness skin graft c. result following the foregoing procedure. Complete removal of lower eyelid as necessary. Allogeneic membrane graft from inside cheek as need to line eyelid

lesions. Excision must extend well beyond the region of marked tissue change regardless of the structure involved. Otherwise progression of the condition is likely to necessitate further surgical removal later. At times during the procedure large blood vessels, nerves, tendons, and other important structures are uncovered and sacrifice of some of these may be necessary. Bony parts fairly frequently are exposed by the ulceration or during removal of the involved soft tissues. In this connection it is well to bear in mind that necrotic bone—especially about the cranium—resulting from irradiation is extremely slow to sequestrate. Often this process will require a year or more, whereas a sequestrum resulting from the use of the actual cautery or electrocoagulation separates within a few months depending on its thickness. Rather than delay closure of the wound until after dead bone has been extruded spontaneously it usually is preferable to remove the bone surgically. As the limits of necrosis frequently are not discernible gross, removal should be made well into freely bleeding omeous tissue. Drilling multiple small perforations through the devitalized bone will permit granulations to develop and at times these will coalesce over the bony surface and permit of covering it with a graft, but actual removal of the involved bone is preferable.

Excision of the soft tissues need not necessarily extend entirely beyond the region of sclerosis and telangiectasia, for while it may be desirable to get

rid of all of the involved tissue its complete eradication might produce a defect of such extent that repair would be extremely difficult. Then too some lessening of the degree of postirradiation change in this peripheral zone usually occurs after removal of the more severely damaged tissues, probably largely the result of subsidence of the inflammatory reaction. Removal may be carried out either sharply with the electrocoagulation scalpel. The latter is advantageous when secondary closure of the wound is planned, since the vascular oozing can be controlled more readily, but it may be employed even though immediate skin grafting is to be done. A graft will usually take readily on a surface thus prepared unless undue searing has been necessary. The line of demarcation between the involved and normal tissues as a rule is readily recognized and separation is easily effected. Severe bleeding usually is not encountered provided there is not excessive acute inflammatory reaction.

The method of repairing the defect following removal of a lesion of this type depends on several factors. Chief among these are the situation and extent of the involvement, the age and sex of the patient, and the presence or absence of epithelioma. Regions of actinodermatitis of limited expanse can be excised a few times and the wound sutured primarily after the edges have been undercut widely. Care should be exercised to extend the incisions proximal parallel to the normal cleavage lines of the skin, unless this will



Fig 8a



Fig 8b



Fig 8d

entail sacrifice of an undue amount of normal tissue, and also to support the subcutaneous tissues well with fine silk sutures and to approximate the margins of the skin accurately so as to render the operative scar as inconspicuous as possible

Benign lesions of considerable spread, if not infected, can be removed advantageously at times by means of multiple partial excisions. According to this procedure, which frequently is of value also in dealing with other types of superficial nonmalignant processes, a portion of the region of such width that the margins of the defect following its removal can just be approximated is excised and the wound is sutured. Several months are then allowed to elapse in order to permit the adjacent skin to relax. Further excision is then carried out and the process is repeated subsequently until the entire lesion is eradicated. This method often permits of removing regions of considerable expanse without producing distortion and leaves only a single fine line scar.

With wide involvement, especially adjacent to fixed points, such as about the nose and ears, free skin grafts or pedicle flaps usually are necessary for repair. The type of skin graft or flap best suited for the purpose will depend on the problems presented by the individual case. In general, free skin grafts are preferable to pedicle flaps about the face and neck when conditions permit of their use because of the saving of time, the shorter period of hospitalization required, and the more satisfactory cosmetic result. Gillies and McIndoe expressed their preference for the use of so called thick razor or split skin grafts in these cases but our own preference is for full thickness grafts, provided satisfactory skin is available and the rather definite contraindications to their use

Fig 8 a, Squamous cell epithelioma (grade 2) originating in actinodermatitis resulting from treatment of goiter about 20 years previously, b, lateral thoracic flap used in correction, c, posterior end of flap transferred for repair, d, result following removal and repair

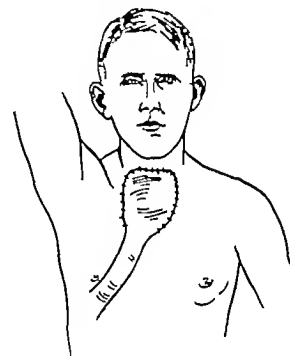


Fig 8c

do not exist. When superficial ulceration and a good deal of inflammatory reaction are present the healing period can at times be shortened greatly by excision of the affected tissue and application of a thin shaved graft. Such grafts usually do well even in the presence of rather acute reaction. With healing complete, the inflammatory process subsides promptly, and the parts covered by the thin graft can then be re-covered with either a full thickness skin graft or a pedicle flap for improvement of its appearance or function.

Full thickness skin grafts possess greater body, are more resistant to trauma, contract very little, and as a rule present a better cosmetic appearance than thin grafts. They should not be used in the presence of infection or in areas that cannot be kept free from contamination and that cannot be immobilized. With these conditions under control, dissected grafts do very well indeed, although, as has been repeatedly emphasized, the technique of their application is very exacting. Lesions of considerable extent about the face and neck can be covered with a single graft of this type cut accurately to pattern, but, in some instances,



Fig. 9 a, and b, Radium dermatitis with sloughing and necrosis of bone from treatment of malignant tumor of mandible 3 years before, c, tubed back flap for correction, d, lower end of flap transferred for repair e, result.

because of the difficulty of immobilization, it is preferable to apply grafts in such areas in stages. In addition this frequently offers a much better chance of a successful take. According to this plan a portion of the lesion is excised and a graft is applied to the wound. After healing is complete a portion or all of the remainder of the pathological tissue is taken care of in the same manner and, if necessary, the process is repeated subsequently until eradication is complete. By immobilization of the mandible with interdental wiring or by other means, counterpressure is secured so that the application of large grafts about the cheeks and lips is feasible. So called split skin grafts and other thinner grafts removed with the dermatome can be applied to extensive wounds on the face or elsewhere about the body with an excellent chance of taking even in the presence of contamination.

While such grafts contract a good deal and often are greatly wrinkled for a time, the ultimate cosmetic result as a rule is not displeasing.

With deeper involvement present, repair will require the use of some type of pedicle flap. The location, size, and form of this must be determined by the situation and extent of the involvement. In most instances the flap should be prepared in advance and removal of the lesion delayed till the former is ready for transfer. There is always the possibility of an error of judgment in this connection, and the region of radiodermatitis or the malignant process superimposed on it may prove more extensive than it had appeared on clinical examination, so that the flap will not be large enough to cover the defect. However by shifting the adjacent tissues this usually can be compensated for. In any event it



Fig 10 a and b, Actinodermatitis involving the entire neck and the lower portion of the face resulting from treatment for scarring and excessive growth of hair in these

regions 16 years previously, c, lower end of lateral thoracic flap transferred to neck, d and e, entire flap encircling the neck, being attached only at either end, f, result of repair

always is advisable to make the flap appreciably larger than has appeared necessary

Thick contaminated lesions in regions such as the base of the neck where the application of a free skin graft would leave an unsightly depression can be replaced satisfactorily at times with a double pedicle flap in a single stage. After

removal of the affected tissue with a wide ellipse, a skin flap of sufficient width to cover the area is elevated at the lower border of the wound and left attached at both ends. This is shifted to cover the denuded region and sutured in place while a skin graft is applied to the site from which the flap was taken. The more conspicuous portion of

the repair is thus concealed by the patient's clothing. The same objective can be accomplished with a flap having a single pedicle but a multiple stage procedure and so more time are required.

Various types of flaps from the forehead or temporalfrontal region that is, the oblique transverse and semicircular serve ideally for repair following removal of regions of radiodermatitis involving the nose, cheeks, or upper lip. Preliminary skin grafting of the undersurface of such flaps permits of their use when sacrifice of the full thickness of any of these structures has been necessary. The repair can be carried out in a minimum of time because of the proximity and the vascularity of these tissues, and the end result is highly satisfactory because of their color and texture. Use of such flaps is restricted largely to women however because of the conspicuous scarring left on the forehead. It is limited also by their size and the extent of their reach.

For correction of defects resulting from extensive radiodermatitis and necrosis about the lower portion of the face and neck, use of a tubed flap from some portion of the trunk is usually required.

Although at times we have employed a flat pedicle flap from the anterolateral aspect of the arm for the purpose. This latter form of flap possesses the advantage shared by the tubed flap of a folding additional scarring on an exposed surface but the area from which it is removed cannot be sutured primarily and must be covered with a free skin graft. As a consequence the donor site is scarred rather badly. However most of the female patients who have such lesions have already lost the desire to wear evening gowns so that the scarring is of little consequence. Actually the flap possesses little advantage over tubed flaps except that it obviates scarring of the chest or back. The time requirement is somewhat shorter but the color is similar to that of flaps from the trunk. Many of the tubed flaps in women are obtained from the back and the skin in this situation is usually coarser than that on the arm.

The region from which a tubed flap is to be secured will depend on the situation and extent of the involvement. For a localized area about the lower part of the face and neck, an craniocervical flap extending parallel to the clavicle and below it often is most satisfactory. The ataxial attachment is transferred. This type of flap has a wide range of application because of the mobility of the shoulder. For more extensive lesions, flaps of this type extending vertically in the lateral thoracic region or transversely on the lower portion of the chest, one end of which may be swung directly to the involved region, or

abdominal flaps transferred by attachment to the wrist are likely to be required. In a case in which radiodermatitis was taken care of some years ago involvement of the skin and subcutaneous tissue of the entire neck and lower portion of the face was present and a lateral thoracic flap of sufficient length to encircle the neck was required.

The results of the surgical treatment of radiodermatitis in most instances are highly satisfactory as regards relieving the patient's symptoms, correcting existing deformity and restoring function. The symptoms, which usually are trying and of long duration, are relieved almost at once on removal of the involved tissue. This is true even though the wound is not closed immediately. It is true also in cases in which malignancy change has occurred. As there is comparatively little tendency for neoplasms developing as a result of radiodermatitis to metastasize until well advanced, an excellent chance of cure is afforded by wide removal in a reasonably early stage. Plastic correction is always one of the chief problems, and the result of repair will naturally vary with the features presented by the individual case and the experience of the surgeon.

Figures 10 to 20, inclusive illustrate the conditions in various cases before operation, the operative methods used, and the results of operation.

#### SUMMARY

Radiodermatitis often is more serious than the condition for which treatment was given primarily. Overexposure during diagnostic or therapeutic procedures usually is responsible for such lesions but individual susceptibility is an important etiological factor. The acute stage of the disease is self-limiting unless excessive reaction is present, and surgical treatment is contraindicated during this period. The chronic stage of the process is progressive and there is a decided tendency for epithelioma to develop. Surgical removal is the only means of controlling the condition when secondary irradiation changes are pronounced. Primary closure of the wound is at times possible following excision of the region of radiodermatitis. When this is not feasible application of a free skin graft or use of a sliding flap or a pedicle flap is required. The ultimate result in these cases as a rule is satisfactory.

#### REFERENCES

1. COWIE, F. A. *Philadelphia M. J.* 902, 9: 417-447.
2. GLENN, H. L. and M. J. BOB. *A. M. Brit. J. Radiol.* 914, 32: 47.
3. LEROY, E. T. *Am. J. Roent.* 96: 510-5.
4. S. ANDER, T. S. and MONTGOMERY, H. (Montgomery). *Am. M. Ass. J.* 95, 1-3.
5. BLOCH, W. *B. J. Med. Res.* 900, 447.

## MALIGNANT TUMORS OF THE KIDNEY

### Surgical and Prognostic Significance of Tumor Thrombosis of the Renal Vein

JOHN R. McDONALD, M.D. and JAMES I. PRUSHTY, M.D., F.A.C.S.,  
Rochester, Minnesota

**T**HE prognostic significance of metastatic involvement of the regional lymph nodes in cases of carcinoma of the breast, stomach or colon is well known. It is recognized that malignant tumors of the kidney have a tendency to invade the renal vessels. This is especially true of carcinoma of the renal cortex which is commonly called hypernephroma. In an occasional case the resulting thrombosis has extended into the inferior vena cava and in rare instances it has extended into the heart.

The recognition of a tumor thrombus in the renal vein in the presence of renal neoplasm is of importance from a surgical as well as a prognostic point of view. At the time of operation the surgeon always adheres to certain principles in mobilization of the growth because of the possible existence of a tumor thrombus. Furthermore, he determines as early as possible during the course of the operation whether or not such a thrombus actually exists. If it is found certain special procedures must be employed in order to deal with it properly and thereby reduce the risk of operation and enhance the likelihood of ultimate survival of the patient.

Judd observed involvement of the renal vein in 22.5 per cent of 200 cases of carcinoma of the kidney. Judd and Scholl reported a case of hypernephroma in which fatal pulmonary embolism occurred while nephrectomy was being performed. The source of the embolus was a thrombus in the renal vein. Of the few authors who appear to have recognized that involvement of the renal vein adversely affects the period of survival after operation in cases of malignant tumor of the kidney, we can mention Hind and Broders. They reported that the renal vein was involved in 38 or 19.6 per cent, of 193 cases of carcinoma of the renal cortex. The average period of survival after nephrectomy was 59 months in cases in which the renal vein was not involved whereas it was only 48 months in cases in which the renal vein was involved. The present report is based primarily upon a study of the incidence

of this complication in the presence of renal neoplasm and its importance in the ultimate rate of survival following nephrectomy.

#### METHOD OF STUDY

In order to determine the incidence of tumor thrombosis of the renal vein and the effect of such thrombosis on the ultimate survival rate after nephrectomy for malignant neoplasm, a dissection was made of the vein, artery, and their tributaries in the hilum of every kidney that had been removed because of a malignant neoplasm at the Mayo Clinic in the years 1903 to 1940 inclusive. In all approximately 700 kidneys were examined. Of necessity a number of kidneys were so mutilated that structures in the hilum evaded identification. In other cases, only the tumor had been saved. These specimens were discarded from the series; therefore 636 kidneys containing malignant neoplasms were included in this study. Only that portion of the renal vein and artery and their tributaries which lay outside the renal parenchyma was examined. No attention was accorded vascular involvement by malignant neoplasm within the kidney because the renal vein and artery rapidly lose their muscular tunics on entering the kidney which makes their identification difficult and often highly questionable because of the liability of confusing vessels with artifacts. No attempt was made to investigate the accessory renal vessels as this was felt to be impractical. The gross examination of the vein and artery usually sufficed to indicate whether a tumor thrombus was present. If it was present a block of tissue from the involved vessel was obtained from which a histological section was cut and stained with hematoxylin and eosin. When any doubt existed as to whether the vessels in the hilum were or were not involved, a block was cut from the doubtful vessel and a histological section was made. In every instance, histological sections of the tumor itself were examined. This was the procedure which was followed in regard to all malignant neoplasms of the kidney. Carcinomas of the renal pelvis required additional investigation.

From the Section on Surgical Pathology and the Division of Surgery, Mayo Clinic.



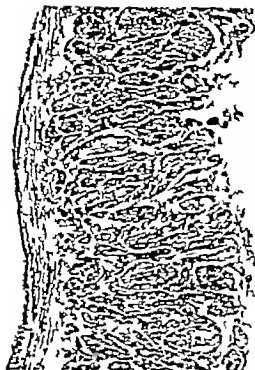


Fig. a, left, Main renal pelvis adjacent to the internal ureter showing the relatively insignificant layer of circular smooth muscle; exterior to this are well developed longitudinal bundles of



smooth muscle (hematoxylin and eosin, X115). b, Main renal artery showing the well developed internal and external elastic tissue laminae (hematoxylin and eosin, X115).

The epithelium of the urinary bladder, ureter and pelvis of the kidney is comparable in histological appearance as well as origin. It is a well known fact that carcinomas of the urinary bladder

TABLE 1.—INCIDENCE OF TUMOR THROMBOSIS OF RENAL VEIN AND INVOLVEMENT OF PERINEURAL LYMPHATICS IN 636 CASES OF MALIGNANT TUMORS OF THE KIDNEY

Type of tumor	Cases		Tumor thrombosis of renal vein or involvement of lymphatics or both	
	Number	Per cent	Number	Per cent
Hypertrophied	209	36	175*	84
Squamous cell carcinoma	76		33	43
Wilms' tumor	31		1	3
Sarcoma	20		1	5
Total	336	59.9	210	62.5

\*Perineural lymphatics involved in only one case.

†Perineural lymphatics involved in one case.

‡Lymphatics not involved.

exhibit a predilection to metastasize by way of the lymphatics to the regional lymph nodes. There is no denying the fact that metastasis does take place through the vascular system to remote organs. It is to be expected that carcinoma of the renal pelvis arising from epithelium similar to that found in the urinary bladder would behave in a similar fashion and metastasize both by the lymphatics and blood vessels.

Blocks of tissue were cut from the hilum of every kidney showing carcinoma of the renal pelvis and histological sections were made and examined. One block included the main renal artery and adjacent tissue. This was done because it was found that the perineural lymphatics in the hilum were frequently involved in kidneys affected with squamous cell carcinoma of the pelvis and one of the surest and easiest places to identify lymphatics in the hilum of the kidney is immediately adjacent to the nerves. Nerves constantly have lymphatic sheath round them. For this reason, in studying the metastasis of malignant neoplasms of the kidney by way of the lymphatics, those around the nerves were chosen as being most



Fig 2 Gross appearance of the hilum of the kidney. The main renal vein and the main renal artery are evident. The renal vein is widely dilated and filled with a malignant thrombus. The primary neoplasm of the kidney is a hypernephroma.



Fig 3 Gross appearance of hilum of kidney. As in Figure 2, the main renal vein and artery are evident, the renal vein is widely dilated and filled with a malignant thrombus, and the primary neoplasm is a hypernephroma.

readily identifiable. Thus all guesswork as to whether one was dealing with lymphatics or artifacts was eliminated. The region around the renal artery was particularly advantageous for the study of the nerves because of their abundance in this region. Of necessity, involvement of the perineural lymphatics is not a gross but rather a histologic observation.

Under ordinary circumstances, the identification of the main renal artery and renal vein was easy. The lumen of the vein is two or three times the size of that of the artery. The wall is thinner and more collapsible than the wall of the artery. Anatomically, the vein is situated characteristically in the anterior portion of the hilum, the artery somewhat more posteriorly, and the ureter with its pelvis more posteriorly still. There is considerable fat between the structures in the hilum of the kidney. The renal nerves in the hilum accompany the arteries. Histologically, the main renal vein is characterized by having an insignificant, circular, smooth muscular tunic adjacent to the intima while external to this is a

very prominent longitudinal smooth muscle coat with the muscle fibers arranged in bundles (Fig 1a). The histological appearance of the wall of the renal vein is very similar to that of the inferior vena cava. The renal artery does not differ from any other medium sized artery having a well formed internal and external elastic tissue lamina (Fig 1b). The renal nerves are of the nonmyelinated variety and easy to identify.

The identification and determination by gross and histological methods of the presence or absence of a malignant neoplasm in that portion of the renal vein, artery or perineural lymphatics situated outside the renal parenchyma was determined in the 636 cases. In not a solitary case was the outcome known to the investigators during the study. In this way there was no opportunity for even an unconscious effort to find involvement of the renal vessels in those cases in which the patients lived a short time, or vice versa, after nephrectomy. All malignant neoplasms were classified and graded at the same time. At the conclusion, the survival rates were tabulated by the Division of Biometry and Medical Statistics.

A few words might be added about the terms used. We have chosen to use the term "hypernephroma" as being synonymous with carcinoma of the renal cortex. It is the general consensus that practically all, if not all, of these neoplasms



Fig. 4 Section of main renal vein and main renal artery. The artery shows no evidence of thrombosis (the vein, however, is filled with malignant thrombus secondary to hypernephroma of the kidney (hematuria and eosin  $\times 30$ )).



Fig. 5 Section of main renal vein and renal artery. The renal vein is highly dilated and filled with malignant thrombus secondary to hypernephroma of the kidney (hematuria and eosin  $\times 30$ ). Size of the vein should be compared with that in Figure 4.



Fig. 6 Section of main renal vein. Primary tumor is hypernephroma of the kidney. The vein is highly dilated and filled with hypernephroma (hematuria and eosin  $\times 30$ ).

originate from renal tubules rather than adrenal rests. There is still considerable controversy as to the fate of so called adenoma of the cortex of the kidney. It is our opinion that this represents an early adenocarcinoma of the renal cortex. However this neoplasm apparently has little or no tendency to metastasize until it reaches certain size. It is decided not to include this controversial neoplasm in this study of hypernephromas consequently only carcinomas of the renal cortex which were more than 3 centimeters in diameter were included. Carcinomas of the renal pelvis are referred to as squamous cell carcinomas because carcinomas of this type often tend to differentiate into renal squamous epithelium including keratinization. Wilms tumor is commonly referred to as embryoma. The sarcomas represent heterologous group. This group are included lymphosarcoma, fibrosarcoma, and leiomyosarcoma.

#### INCIDENCE AND PROGNOSTIC SIGNIFICANCE OF TUMOR THROMBOSIS OF THE RENAL VEIN

The type of malignant tumor encountered in these 636 cases is shown in Table I. It is of interest to note that in 509, or 80 per cent, of the cases the tumor was classified as hypernephroma.



Fig 7 a and b, Section of main renal vein in 2 cases showing nubbin of hypernephroma only partly occluding vein and producing no evidence of complete thrombosis

The firm attachment to intima of vein may be noted. The primary tumor in each was a hypernephroma of the kidney (hematoxylin and eosin, a,  $\times 104$ , b,  $\times 34$ )

ma The relative incidence of the various tumors varies in minor degree from that reported by Priestley in 1939, but, as has been stated previously, it was necessary in this study to eliminate certain neoplasms because the hilum of the kidney could not be identified, in addition, those malig-

nant neoplasms of the kidney which were removed in the years 1937 to 1940 inclusive are included in this study. For statistical purposes in computing the survival rate, only the patients who were operated on prior to January 1, 1937, were included. This was done so that all the patients

TABLE II—MALIGNANT TUMORS OF THE KIDNEY. RELATION OF 5 YEAR SURVIVAL RATE TO PRESENCE OF TUMOR THROMBOSIS OF THE RENAL VEIN OR INVOLVEMENT OF THE PERINEURAL LYMPHATICS OR BOTH

	Hypernephroma				Squamous cell carcinoma			
	Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital		Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital	
	Total	Number traced	Number	Percentage of traced patients	Total	Number traced	Number	Percentage of traced patients
No involvement of renal vein or lymphatics	180	186	103	55.4	35	35	15	42.9
Involvement of renal vein and lymphatics	213	0	60	29.0	22	21	1	4.8
Total	393	303	163	41.5	57	56	16	28.6

\*Inquiry as of January 1, 1942. Included here are patients operated on 5 or more years prior to the time of inquiry, that is, 1936 or earlier. Hospital mortality is excluded in the calculation of survival rates.

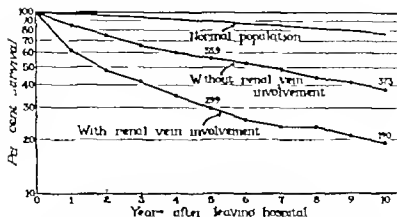


Fig. 8 The survival rates in cases of hypernephroma of the kidney compared with that of the normal population of the same ages as that of the patients with hypernephroma. Curves are plotted on the logarithmic scale.

would have been operated on a sufficient number of years prior to the investigation. Operative deaths and the cases of those patients who could not be traced were not considered in calculating the survival rate.

As might be expected, the hospital mortality rate was slightly higher in cases in which tumor thrombosis was found in the renal vein (8 per cent) than it was in cases in which such thrombosis was not present (6 per cent). This can readily be explained by the fact that hemostasis is more difficult to obtain in cases in which thrombosis is present. In addition, a thrombus in the renal vein occasionally may break loose at the time of surgical manipulation and cause pulmonary embolism.

#### HYPERNEPHROMA

In 509 of the 636 cases, the renal tumor was a hypernephroma (Table I). Malignant thrombosis of the renal vein (Figs. 2 and 3) was present in

275 or 54 per cent of the cases of hypernephroma. It is worthy of repetition that in this paper the term renal vein has been used to designate one of the veins in the hilum of the kidney. In most cases, the main renal vein or one of its primary divisions. There was no evidence of neoplastic involvement of an artery in any of the cases of hypernephroma. In a number of cases, histological examination disclosed endarteritis of the main renal artery occasionally with benign thrombosis but neoplastic involvement could not be demonstrated. Involvement of the perineural lymphatics was observed in only 1 case. Tumor thrombosis of the renal vein also was present in this case.

The neoplastic cells apparently enter the venules in the region of the tumor and invade the larger veins by continuity. No other carcinoma exhibits this tendency to such a marked degree. That the arterial tree is not invaded is best

TABLE III—HYPERNEPHROMA OF THE KIDNEY: RELATION OF 5 YEAR SURVIVAL RATE TO GRADE OF MALIGNANCY AND THE PRESENCE OF TUMOR THROMBOSIS OF THE RENAL VEIN

Malignancy	No involvement of renal vein				Tumor thrombosis of renal vein			
	Patients who survived operation*		Patients who lived 5 or more years after discharge from hospital		Patients who survived operation*		Patients who lived 5 or more years after discharge from hospital	
	Total	Number traced	Number	Percentage of traced patients	Total	Number traced	Number	Percentage of traced patients
Grade III	140	140	86	62	145	145	31	21
Grade II	26	26	-	0	-	-	-	-
Total	166	166	86	52.4	145	145	31	21

\*Majority as of January 1, 1941. Included here are patients operated on 5 or more years prior to the time of survey. That is, 12.6 or earlier. Hospital mortality included in the calculation of survival rates.

explained by the fact that the arterioles unlike venules have a more definite wall which is probably sufficient to prevent carcinoma cells from entering the arterioles. It is not surprising that the lung is the usual site of metastatic involvement in cases of hypernephroma. This may be explained by the lack of lymphatic involvement in the hilum of the kidney and by the relative absence of metastatic involvement of the regional lymph nodes. Bizarre metastatic involvement of the spinal column can readily be explained by anastomosis of the renal veins with those of the paravertebral venous system, which has been described by Batson. In cases in which thrombosis of the main renal vein is present, the vein may be normal in size but it usually is dilated (Figs 4 and 5), in some cases, the diameter of the lumen may be increased ten times (Fig 6). The thrombosis may extend a varying distance along the renal vein, at times, it even may involve the inferior vena cava. It becomes firmly attached to the intima of the vein as it grows (Figs 7a and b). It acquires its blood supply from the wall of the vessel as it grows, and thus behaves as a sort of parasite. This is a very important phenomenon to recognize as when a tumor thrombus is present in a renal vein it is not sufficient for the surgeon to "milk" the thrombus in the vein toward the kidney and then cut the vein where the thrombus was originally attached. By so doing, neoplasm will inevitably be left attached to the wall of the remnant of the renal vein. It is necessary to excise the vein beyond the site of attachment of the thrombus, that is, on the side of the vena cava.

In the cases of hypernephroma, the mortality rates in the first year after the patients were dismissed from the hospital were as follows: 38 per cent in the cases in which tumor thrombosis of the renal vein was present at the time of operation and

only 18 per cent in the cases in which tumor thrombosis was not present. This is another indication that tumor thrombosis of the renal vein seriously affects the prognosis in cases of hypernephroma. The 5 year survival rate in both groups of cases was 41.5 per cent (Table II). It is of interest to note that it was 55.4 per cent in cases in which tumor thrombosis of the renal veins was not encountered at operation and only 29 per cent in cases in which thrombosis was not present. The survival rates are shown graphically in Figure 8.

In the cases in which tumor thrombosis was present, it seems reasonable to assume that showers of malignant emboli must have occurred into the venous circulation and especially in the lungs. It is a wonder that actual metastatic lesions were not present in the lungs in all of these cases. It is apparent that few of these emboli acquire a parasitic blood supply and those that do live occasionally undergo regression after removal of the primary neoplasm.

The relation of tumor thrombosis of the renal vein and the grade of malignancy, as determined by the method of Broders, is shown in Table III. Tumor thrombosis was present in 49.8 per cent of the cases in which the hypernephroma was grade 1 or 2 and in 61.9 per cent of the cases in which the tumor was grade 3 or 4. It is apparent, therefore, that even hypernephromas of low grade have a great tendency to invade the renal vein. Table III reveals that the presence of tumor thrombosis of the renal vein tends to increase the gravity of the prognosis regardless of the grade of the primary tumor.

Table IV shows the relation of tumor thrombosis of the renal vein to the weight of the involved kidney, that is, the weight of the kidney and the hypernephroma. The incidence of tumor throm-

TABLE IV—HYPERNEPHROMA OF THE KIDNEY RELATION OF 5 YEAR SURVIVAL RATE TO THE WEIGHT OF THE INVOLVED KIDNEY AND THE PRESENCE OF TUMOR THROMBOSIS OF THE RENAL VEIN

Weight of involved kidney grams	No involvement of renal vein				Tumor thrombosis of renal vein			
	Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital		Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital	
	Total	Number traced	Number	Percentage of traced patients	Total	Number traced	Number	Percentage of traced patients
0 to 499	66	65	35	53.8	45	45	15	33.3
500 to 999	56	55	30	54.5	80	76	20	26.3
1000+	28	28	13	46.4	48	48	0	18.7

\*Inquiry as of January 1, 1942. Included here are patients operated on 5 or more years prior to the time of inquiry that is 1936 or earlier. Hospital mortality is excluded in the calculation of survival rates.



Fig. 9. Hilum of the kidney removed surgically for carcinoma originating in renal pelvis. The main renal artery is center of hilum and main renal vein is to the right. The larger tumor than the artery are areas of red (hemorrhagic) and areas (X 5). Areas 1 and 5 shown under higher magnification as figures 10 and 11 respectively.



Fig. 10. Carcinoma of the pelvis of the kidney. Section from hilum of kidney shows in Figure 9, area lymphatics surrounding the area are filled with carcinoma cells. The carcinoma cells have produced pseudocystic effect (hemorrhagic and areas X 70).

basis according to the weight of the involved kidney was as follows: 40.6 per cent in cases in which the involved kidney weighed less than 500 grams, 58.8 per cent in cases in which it weighed 500 to 1,000 grams and 63.1 per cent in cases in which it weighed 1,000 grams or more. It was found that the incidence of tumor thrombosis of the renal vein increased slightly with the weight of the involved kidney. Table IV also shows the 5 year survival rate according to the weight of the involved kidney and the presence or absence of tumor thrombosis of the renal vein.

Infarction of a portion of the tumor in the kidney is a very common complication of hypernephroma. Usually this phenomenon as it occurs elsewhere in the body that such infarction of the tumor would appear to be of the thrombotic type.

cases Involvement of the perineural lymphatics in the hilum of the kidney (Figs 9, 10 and 11a) was present in 23 of the 34 cases Tumor thrombosis of the renal vein (Figs 11a and b and 12a) was present in 20 or 86.9 per cent, of the 23 cases in which there was involvement of the perineural lymphatics In one of the 20 cases, thrombosis of the renal artery also was present (Fig 12b)

Because the lymph and blood vessels of the hilum of the kidney are so close to the epithelium of the renal pelvis, it is not surprising that tumor thrombosis of the renal vein and involvement of the perineural lymphatics are rather common in cases of carcinoma of the renal pelvis It is more surprising that they are not encountered more frequently In cases of carcinoma of the renal pelvis, metastasis usually occurs in the periaortic lymph nodes or in the lungs

The 5 year survival rate is shown in Table II In cases in which tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both were present, only 1 patient is known

to be alive 5 years after dismissal from the hospital

#### WILMS' TUMOR

Tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both were present in 14, or 45.2 per cent, of the cases of Wilms' tumor (Table I) The perineural lymphatics were involved in 2 cases Tumor thrombosis of the renal vein also was present in 1 of these cases Considerable necrosis was observed in 2 of the cases in which tumor thrombosis of the renal vein was present In these cases, radiotherapy apparently had produced necrosis of the tumor thrombus The presence of tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both apparently had little influence on the 5 year survival rate in the cases of Wilms' tumor

#### SARCOMA

Tumor thrombosis of the renal vein was present in 2 of the 20 cases of sarcoma of the kidney

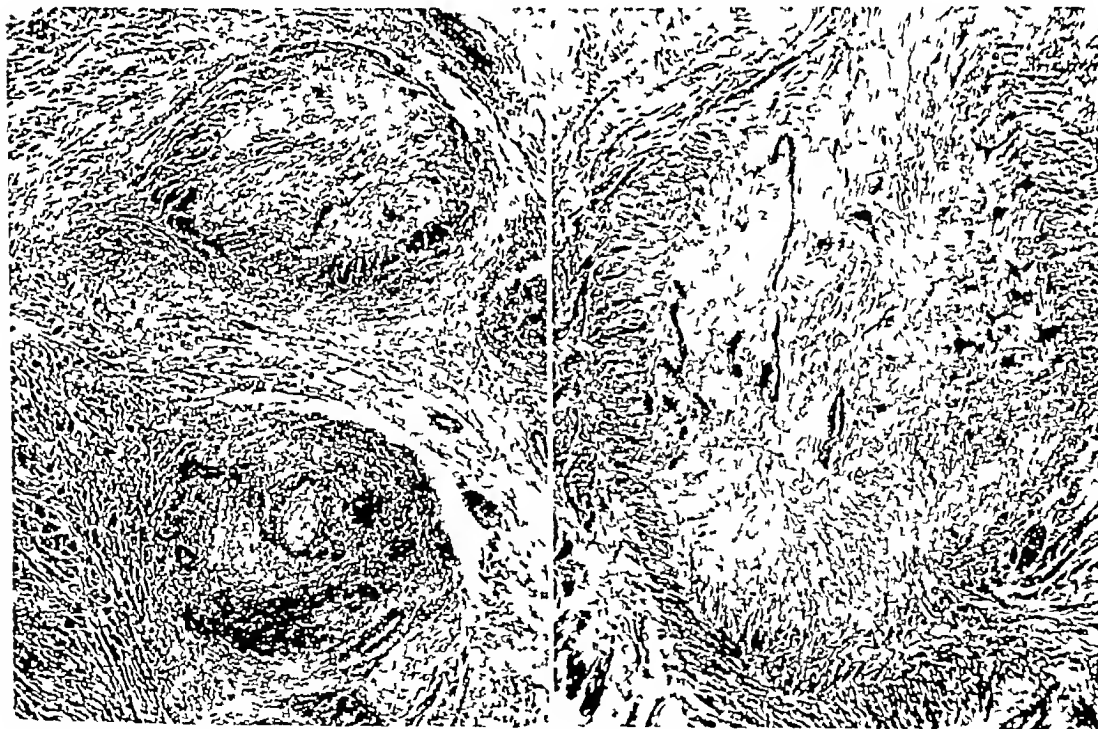


Fig 11 Carcinoma of pelvis of kidney a, left, A small vein and nerve in the hilum of the kidney taken from area 2 in Figure 9 The vein is completely thrombosed showing much fibrous tissue and a few strands of squamous cell carcinoma (hematoxylin and eosin  $\times 39$ ) The lymphat

ics around the nerve are sheathed with carcinoma cells b, A larger vein taken from area 3 in Figure 9 Its muscular walls are completely thrombosed with fibrous tissue containing a few strands of carcinoma cells (hematoxylin and eosin  $\times 24$ )





Fig. 9. Hilum of the kidney removed surgically for carcinoma originating in renal pelvis. The main renal artery is center of hilum and main renal vein (which had larger lumen than the artery) are encircled (hematoxylin and eosin  $\times 3.5$ ). Areas 1 and 4 shown under higher magnification in Figures 10 and 11 respectively.



Fig. 10. Carcinoma of the pelvis of the kidney. Section from hilum of kidney shown in Figure 9, area 1. The lymphatics surrounding the nerve are filled with carcinoma cells. The carcinoma cells have produced 'pseudocystic' effect (hematoxylin and eosin  $\times 70$ ).

bases according to the weight of the involved kidney was as follows: 40.6 per cent in cases in which the involved kidney weighed less than 500 grams, 58.8 per cent in cases in which it weighed 500-1,000 grams and 63.1 per cent in cases in which it weighed 1,000 grams or more. It was found that the incidence of tumor thrombosis of the renal vein increased slightly with the weight of the involved kidney. Table IV also shows the 5-year survival rate according to the weight of the involved kidney and the presence or absence of tumor thrombosis of the renal vein.

Infarction of a portion of the tumor in the kidney is a very common manifestation of hypernephromas. Usually hemorrhage accompanies this phenomenon as it does infarction which occurs elsewhere in the body. It would appear likely that such infarction is the result of thrombosis of the veins.

#### CARCINOMA OF THE RENAL PELVIS

In 76, or 19 per cent, of the entire series of cases of malignant tumor of the kidney the neoplasm was a carcinoma of the renal pelvis (Table I). Involvement of the perineural lymphatics in the hilum of the kidney or tumor thrombosis of the renal vein or both were present in 34, or 44.7 per cent, of the cases of carcinoma of the renal pelvis (Table I). Thrombosis of the main renal vein or of one of its smaller branches in the hilum of the kidney was present in 3 of the 34

vein, as he can in most cases, whether or not a tumor thrombus is present in this vessel. If none is found, clamps may be applied promptly in an appropriate manner to the renal pedicle, and the kidney may be removed. If a tumor thrombus is found it will have to be dealt with in one of several ways, depending on its size and the degree of involvement of adjacent structures. It should be remembered, as will be mentioned later in more detail, that the wall of the vein becomes involved by the malignant process in the presence of a tumor thrombus. This means that the portion of the vein to which the thrombus is attached also must be removed if all tumor tissue is to be removed. Usually, however, there is a short projection of the thrombus centrally in the vein beyond the most proximal point of attachment to the wall of the vein.

The easiest type of tumor thrombus to deal with is the one which extends for such a short distance in the renal vein that there is enough uninvolved portion of the renal vein for the application of clamps between the thrombus and the vena cava. Such a case offers no particular problem except that care should always be taken not to dislodge the thrombus and not to include any of it in the clamps. In other cases it may be found that the thrombus extends almost to the vena cava so that there is space for the application of one clamp only between the end of the thrombus and vena cava. Under these circumstances this clamp should be applied to the renal vein and the tumor removed. Any involved portion of the renal vein distal to the clamp may then be excised and the remaining portion may be utilized for obtaining hemostasis either by ligature or suture. When circumstances are unfavorable because of difficulty of exposure, poor condition of the patient or other reason, one or more clamps may be left in place on the renal vein with safety. These are loosened in 48 hours and removed in 72 hours. Fortunately, the renal artery in cases of hypernephroma is practically never involved with tumor thrombus and, therefore, the arterial blood supply to the kidney may be controlled in the usual manner.

In the event that the tumor thrombus extends from the renal vein into the vena cava, a more serious and difficult problem is presented. When this occurs on the left side it is seldom if ever that all involved tissues can be removed. If involvement of this type is found on the right side, where the vena cava is more accessible, the extension of the tumor into the vena cava usually can be removed unless it is too massive. In case there is a relatively small extension into the vena cava one

may be able to expose this vessel above and below the region of involvement. The flow of blood in the vena cava then is controlled in one of several ways. The assistant may compress the vessel against the vertebral column with one finger placed above and one finger below the site of the thrombus, or rubber covered Doyen forceps or a serrefine clamp may be placed in similar positions. The surgeon then opens the vena cava, removes the thrombus, and any of the wall of the vena cava that is involved. After removal of the tumor thrombus and while hemostasis is maintained, the vessel is sutured with a single row of oiled silk blood vessel suture material. Removal of such a thrombus will make the difference between certain failure and at least the possibility of a satisfactory ultimate result. Of course, in some cases it may be impossible to remove thrombotic extension into the vena cava, particularly if this is quite extensive and perhaps has extended both proximally and distally in the vein.

#### COMMENT

In cases of hypernephroma of the kidney, the presence of tumor thrombosis of the renal vein is of definite prognostic significance. The prognostic significance is comparable to that of involvement of the lymph nodes in cases of carcinoma of the breast or gastrointestinal tract. The main veins in the hilum of the kidney can be examined more easily and more quickly than can a group of lymph nodes. Five or ten seconds usually is sufficient to determine the state of the renal vein and its tributaries.

In cases of carcinoma of the renal pelvis, the prognostic significance of tumor thrombosis of the renal vein or involvement of the lymphatics is greater than it is in cases of hypernephroma. Involvement of the lymphatics can usually be determined only by histological examination. The lymphatics about the nerves can be identified most readily.

In addition to the grade of malignancy as determined by the method of Broders and the presence of tumor thrombosis of the renal vein or involvement of the lymphatics, there are other factors that obviously affect the prognosis. The most significant of these factors is involvement of the perirenal fat or structures adjacent to the kidney. In this study, the perirenal structures were not examined as the specimens had been fixed with formaldehyde. In some cases, the specimens had been fixed 40 years before this study was made. It, therefore, was our opinion that the results of examination of the perirenal structures would be inaccurate. When it is a



Fig. 2. a, left, Section of main renal vein taken from kidney removed surgically for squamous cell carcinoma of the renal pelvis. The vein is thrombosed and the squamous cell carcinoma is evident within the lumen of the vein (hematoxylin and eosin  $\times 14$ ). b, Another section demonstrating

the internal elastic lamina, completely thrombosed, with fibrous tissue in which are evident a few strands of carcinoma. The primary neoplasm in this instance is squamous cell carcinoma of the renal pelvis (hematoxylin and eosin  $\times 36$ ).

(Table I). Involvement of the perineural lymphatics was not encountered in any of these cases. In cases of sarcoma of the kidney the presence of thrombosis of the renal vein did not appear to be of prognostic significance.

#### SURGICAL CONSIDERATION

From the surgeon's point of view, as mentioned previously, it is always important to bear in mind the possibility of involvement of the renal vein by a thrombus composed of tumor tissue when undertaking the removal of malignant renal neoplasm. If one handles the kidney too roughly or injures it unnecessarily in any manner it is entirely possible that a portion of such a tumor thrombus may be broken loose and enter the vena cava. Under these circumstances the patient receives a direct intravenous injection of viable tumor cells which would be expected to give rise to metastatic lesions. It seems quite likely that, in certain cases, metastatic pulmonary lesions which become apparent soon after nephrectomy

for malignant neoplasms of the kidney may be accounted for in this manner.

In order then, to avoid breaking loose a possible tumor thrombus in the renal vein, the surgeon always handles a renal neoplasm as gently as possible. It is compressed, pulled on and normally manipulated in any other manner to a minimal degree. As soon as possible during the course of the operation the surgeon identifies and isolates the renal pedicle. For the purpose of gaining more rapid access to the renal pedicle some surgeons have advocated a transperitoneal approach for the removal of a renal neoplasm. It has not been our experience that this approach is of particular value unless one is dealing with a tumor of exceptional size. Rapid mobilization of the kidney is facilitated by more or less disregarding the enlarged veins which may surround the kidney as bleeding from them will be almost completely controlled when the renal pedicle is secured.

After satisfactory exposure of the pedicle the surgeon first determines by palpation of the renal

# CONGENITAL DISLOCATION OF THE HIP WITH SPECIAL ATTENTION TO THE AFTER-CARE PERIOD AND LATE POSTREDUCTIVE RESULTS

GORDON WHISTON, M.D., Casper, Wyoming

**A**LTHOUGH congenital dislocation of the hip was recorded in ancient times, its pathological anatomy was not dealt with until the work of Paletta in 1820 and then carefully described by Dupuytren in 1826 (Tubby, 1929). Throughout the following years, the literature has been generously supplied with the clinical aspects of the congenital hip.

Like most orthopedic problems, congenital dislocation of the hip requires as careful and thorough attention to details in the after care period as that given during the operative phase. Although each case presents an individual problem, certain basic principles must still be followed even though radically modified to suit both the patient and surgeon. These principles were carefully noted and their merits studied in a series of cases collected both in England and the United States. Of the 48 cases in this series which were treated and then, except for 2 cases, observed for 10 years or more, the majority were examined personally by the writer and the functional and anatomical end-results were recorded.

Congenital dislocation of the hip, a clinical entity that might better be expressed as congenital misplacement of the hip, for its etiology is still largely a matter of conjecture and theory, is not a rare deformity. It is observed more frequently in certain sections of the United States, particularly in the northern states. Outside of the Western Hemisphere, the largest incidence occurs in Italy and France, and at the Rizzoli Institute in Bologna, 3,216 cases had been treated in 33 years (Putti, 1934).

To evaluate the end-result after treatment of congenital dislocation of the hip, careful consideration has been given to the method employed to obtain the reduction, the position and period of immobilization, and complications that might have influenced the final result. Unfortunately,

many of the case records were lacking in fine detail but all available data were obtained from them and reproduction of all roentgenographs on each case was made for the purpose of further study.

## METHODS OF REDUCTION

The closed method of reduction for congenital dislocation of the hip is used for the majority of patients treated in the clinics from which this series was collected and studied. Forty-four of the 48 cases in this group were treated by the closed manipulative method, and the technique described by Lorenz was followed in 41 of these 44 cases. In accordance with the teachings of Lorenz, the present writer was assured in the clinics from which the case records and patients were studied, that the hips were manipulated gently and without undue force. The procedures of Lange, Calot, and Radlton were used for the 3 remaining patients treated by the closed method, Cases 27, 40, and 43, respectively (Table II).

Open operation was performed in only 4 patients in the entire series. Two hips, Cases 29 and 39, were reduced following the removal of a capsular obstruction but the third, Case 34, required remolding of the femoral head before reduction could be accomplished. The remaining case had a shelf constructed over the false acetabulum without an attempt to replace the femoral head in its normal position (Case 26).

## IMMOBILIZATION

The position of immobilization of the hip following reduction by the Lorenz method was that of marked abduction, flexion, and external rotation. The "frog-leg" position of 90 degrees, abduction, 90 degrees, flexion, and marked external rotation was used in all cases in which patients were treated by the closed method, except Case 27 in which the leg was immobilized in abduction, extension, and internal rotation. The "frog-leg" or first position was maintained for a period varying from 1 month in Cases 20, 25, 30, 33, 36, and 39 as a minimum to a maximum of 10 months in Case 45, with an average of approximately 4 months (Table I).

Collection of case studies in England made possible through a travelling fellowship grant from the Nemours Foundation.

Indebtedness and appreciation for the privilege of collecting and use of their cases is expressed to Mr. Harry Platt, Manchester Royal Infirmary, England; Dr. Philip D. Wilson, Hospital for Special Surgery, New York City; and Drs. Lord Schrock and Johnson, Omaha, Nebraska.

case of fresh specimens, it is not difficult to determine whether or not perirenal involvement is present.

It would appear that Wilms' tumor and sarcoma of the kidney metastasize by way of the blood vessels. In many of the cases, there is no involvement of the main renal vein. Neoplastic cells apparently enter the vessels in the kidney and metastasize from this point.

## REFERENCES

1. Brown, O. V. *Ann Surg* 1920, 73: 49.
2. Brown, A. C. The macroscopic grading of cancer. In Pack, G. T. and Livingston, F. M. *The Treatment of Cancer and Allied Diseases*. Vol. 17, 7-1. New York: Paul B. Hoeber Inc. 1930.
3. Focust, G. S. Quoted by Judd, E. S. and Schell, A. J.
4. Hays, J. R. *J Urol* 1932, 29: 6.
5. Judd, E. S. and Schell, A. J. *J Am Med Ass* 1934, 8: 73-75.
6. Roberts, J. T. *J Am Med Ass* 1932, 1: 1002-1005.

TABLE II

Case number	Sex	Unilateral or bilateral	Age at beginning treatment—yrs	Method of reduction	Period of immobilization—mos	Clinical end result	X ray classification (Fairbank)	Time under observation—years
1	F	B	5	Closed	9	Good	R C 2 L C 2	16
2	F	U	2	Closed	11	Excellent	L C 1	15
3	F	B	2	Closed	30	Fair	R AR 2 L AR 2	12
4	F	B	2	Closed	11	Good	R AR 2 L C 2	11
5	F	B	3	Closed	8	Fair	R C 1 L C 2	18
6	F	U	2½	Closed	15	Excellent	L C 1	12
7	F	U	3	Closed	9	Excellent	L C 1	11
8	F	U	11	Closed	7	Fair	R AR 2	17
9	F	U	2	Closed	8	Excellent	L C 1	11
10	F	U	2	Closed	13	Good	R AR 1	11
11	F	U	6	Closed	12	Fair	L C 2	10
12	M	U	6	Closed	9	Good	L C 1	10
13	F	U	2	Closed	12	Good	R C 1	12
14	F	U	5	Closed	10	Fair	L AR 2	16
15	F	B	7	Closed	8	Good	R AR 2 L C 2	15
16	F	B	3	Closed	15	Good	R C 1 L AR 2	10
17	F	U	2	Closed	9	Excellent	L C 1	10
18	F	U	2	Closed	11	Excellent	R C 1	11
19	F	B	6	Closed	6	Fair	R C 2 L --	12
20	F	U	2	Closed	9	Excellent	L C 1	9
21	M	U	1½	Closed	6	Excellent	L C 1	10
22	M	U	3	Closed	9	Good	L C 1	11
23	F	B	6	Closed	6	Poor	R AR 2 L AR 2	10
24	M	B	2	Closed	7	Fair	R C 1 L AR 2	10
25	M	U	3½	Closed	6	Fair	L C 2	10
26	F	U	44	Open	3	Fair	R AR 2	10
27	M	U	1½	Closed	3	Poor	L C 2	10
28	F	U	2½	Closed	8	Fair	R AR 1	11
29	M	U	6	Open	8	Fair	R C 2	12
30	F	B	1½	Closed	7	Good	R AR 2 L C 2	11
31	F	U	4	Closed	20	Excellent	L C 1	12
32	F	U	1½	Closed	6	Good	R C 1	10
33	F	U	2½	Closed	7	Good	L C 2	10
34	F	U	9	Open	3	Good	L C 2	10
35	F	U	1½	Closed	7	Good	R C 2	12
36	F	U	3	Closed	12	Fair	L C 2	10

TABLE II — Concluded

Case number	Sex	Unilateral or bilateral	Age at beginning treatment—yrs	Method of reduction	Period of immobilization—mos	Clinical end result	X ray classification (Fairbank)	Time under observation—years
37	F	U	1½	Closed	6	Fair	L --	16
38	M	U	2	Closed	7	Excellent	L C 1	10
39	F	B	7	Open	5	Poor	R C 2 L C 2	10
40	F	B	3	Closed	15	Fair	R C 2 L AR 2	18
41	F	U	2	Closed	7	Excellent	L C 1	12
42	M	U	4	Closed	12	Poor	L AR 2	10
43	F	U	3½	Closed	16	Poor	R AR 2	12
44	F	U	1½	Closed	8	Good	R C 2	14
45	F	B	2½	Closed	13	Good	R C 2 L C 2	10
46	M	U	2	Closed	9	Good	L AR 1	15
47	M	B	2	Closed	11	Excellent	R C 2 L C 2	7
48	F	B	4	Closed	11	Poor	R AR 2 L AR 2	17

the antetorsion of the femoral neck necessary to secure adequate stability after reduction (Cases 22, 24, 25, 30, and 33). In each case, manual osteoclasis was done just above the femoral condyles and, with the hip held in a position of internal rotation, the distal fragment was rotated outward until the patella faced directly anterior. Manual osteoclasis was performed on 7 femurs in 5 cases and in only 2 hips was the anatomic end-result rated good. This operation may be necessary in the case with marked antetorsion of the femoral neck but derotation takes place as a rule in sufficient degree to result in a stable reduction.

#### COMPLICATIONS

The complications which arise in the treatment of congenital dislocation of the hip are well known and for that reason, only those that occurred in this series of cases will be mentioned. A complication to treatment may be some pre-existing condition as well as some undesirable after-math following reduction. Case 3 presented typical findings of osteogenesis imperfecta congenita prior to the onset of treatment for bilateral congenital dislocation of the hip. Multiple fractures occurred during the period of treatment and prevented retention of the hips after reduction. Both femurs were involved; the left was fractured by a fall while the hips were in the second position without the legs being incorporated in plaster, and

TABLE I

Case number	Technique of reduction	First position (abduction flexion)	Second position (abduction flexion)	Third position (abduction flexion)	Fourth position (abduction flexion)	Antetorsion requiring special treatment
1	Lorenz	90-90	Yes		Yes	None
2	Lorenz	90-90	60-45	90-45		None
3	Lorenz	90-90	15	60-45	90	None
4	Lorenz	90-90	6	60-15	No	None
5	Lorenz	90-90	60-	90-45		None
6	Lorenz	90-90	70-70	Yes		None
7	Lorenz	90-90	Yes	No		None
8	Lorenz	90-90	70-	90-		None
9	Lorenz	90-90	8	No		None
10	Lorenz	90-90	15	Yes	65	Yes
11	Lorenz	90-90	60-	No		None
12	Lorenz	90-90	8	Yes	No	None
13	Lorenz	90-90	70-	90-		None
14	Lorenz	90-90	Yes	Yes		None
15	Lorenz	90-90	Yes	Yes		None
16	Lorenz	90-90	60-45	Yes		None
17	Lorenz	90-90	60-	No		None
18	Lorenz	90-90	6	Yes	No	None
19	Lorenz	90-90	90-	No		None
20	Lorenz	90-90	Yes	No		None
21	Lorenz	90-90	Yes	No		None
22	Lorenz	90-90	Yes	90-		Suprcondylar osteotomy at 20th month
23	Lorenz	90-90	Yes	Yes		None
24	Lorenz	External abduc. Unit	Yes	Yes		Suprcondylar osteotomy at 24th month
25	Lorenz	90-90	90	Yes		Suprcondylar osteotomy at 2nd position
26	Open	Yes	No			None
27	Large	Internal rotation	External rotation	No		None
28	Lorenz	90-90	7-	No		None
29	Open	90-	No			None
30	Lorenz	90-90	Yes	90		Suprcondylar osteotomy at 2nd position
31	Lorenz	Auxiliary abduc. Unit	60-	90-90	8	None
32	Lorenz	90-90	Yes	No		None
33	Lorenz	90-90	15	No		Suprcondylar osteotomy at 20th month
34	Open	90-90	Yes	No		None
35	Lorenz	90-	15	Yes	No	None

TABLE I—Continued

Case number	Technique of reduction	First position (abduction flexion)	Second position (abduction flexion)	Third position (abduction flexion)	Fourth position (abduction flexion)	Antetorsion requiring special treatment	
36	Lorenz	90-90	Yes	No		None	
37	Lorenz	90-90	Yes	No		None	
38	Lorenz	90-90	Yes	Yes		None	
39	Open	60-60	Yes	No		None	
40	Calot	90-90	Yes	Yes		None	
41	Lorenz	90-90	Yes	Yes		None	
42	Lorenz	90-90	Yes	Yes		None	
43	Ridlen	Yes	Yes	Yes	7	None	
44	Lorenz	90-90	Yes	8	No	None	
45	Lorenz	90-90	15	Yes	Yes	None	
46	Lorenz	90-90	Yes	No		None	
47	Lorenz	90-90	Yes	No		None	
48	Lorenz	90-90	Yes	9	Yes	4	None

The Lorenz second position of less abduction, less flexion, and slight internal rotation was used in all patients treated by the closed method, except Cases 9 and 37. Although the second position is sometimes gradually obtained over a period of several days by means of skin traction pulling in the appropriate directions, in the present series the position was secured at the time of change of plaster either with or without anesthesia. The exact position of the hip in the second position was not described in detail in the records of most cases but when present, an attitude of approximately 60 degrees of abduction and 45 degrees of flexion was indicated most frequently. This position was also maintained approximately 4 months (3.8 months). Although a second position was used in all but one case, Case 9, third position of still less abduction, less flexion and increased internal rotation was used in only 24 of the 48 patients treated by the closed method.

#### ANTEVERSION

The problem of antetorsion of the femoral neck has received considerable attention in numerous clinics when the stability of the reduced congenital hip is under consideration. In the newborn the degree of antetorsion has been described by Böhm and, although the transcondylar diameter is 115 degrees in the frontal plane and the head at 45 degrees to the same plane in the average case, this torsion may be considerably greater in the congenital dislocated hip. In only 5 of the 63 hips that are included in this paper was correction of



Fig 4, left. Case 10 K M, female, aged 2 years at time of manipulative reduction X ray film shows right hip dislocated and left hip subluxated (1925)

Fig 5 X ray film made in 1936 shows right femoral head to be nearly normal in configuration but riding opposite the upper lip of the acetabulum Anterior reposition I

head of the femur is in the acetabulum and approaches the normal in size and shape as disclosed by x-ray (Figs 1 and 2) It is to be expected that this group of patients has essentially normal clinical findings Of the 48 cases reviewed, 18 belong in the class I cures and a good or excellent functional result is present in 16 The average age in this group was 3 years at the time of reduction (Table II)

The functional end-result has been rated as excellent when the hip presented practically full range of motion and was painless and stable A good result includes those hips with some limitation of motion but otherwise painless and fairly stable A fair end-result is given to the group of hips that became painful after moderate activity or were moderately unstable in walking or both Limitation of motion was present in most of these cases The poor end-result group contains all other cases not classified in the preceding groups

Among the class II cures, are placed those which show an equally definite anatomical cure, but in which the head of the femur is distinctly abnormal, either in the direction of being mushroomed, varoid, or of being partly or completely worn away by absorptive arthritis, a term used by Fairbank (Fig 3) Nineteen cases were found in this group The functional end-result was good in 9 and fair in 7 One case rated excellent but was only 7 years after reduction The 2 remaining cases were poor (Table II)

In the foregoing groups, the femoral head has been replaced and retained in the acetabulum Unfortunately a considerable number of cases fail to maintain this reduction through some anatomical variation but the femoral head has been changed from a posterior dislocation to an anterior position The anterior repositions are divided into two groups by Fairbank according to the

roentgenological findings Of course, these groups do not include untreated cases, in which the femur remains in its original position posterior to the acetabulum

Anterior reposition I, means that the case presents a fairly well formed rounded head opposite the upper lip of the acetabulum with or without the formation of a false acetabulum at this point Instability is the most prominent symptom in this group although pain may be a major issue (Figs 4 and 5) In this group, 3 cases have been included by their x-ray findings but the functional end-result was rated good in 2 of them, Cases 10, 28, and 46 (Table II) The other case being classified as fair

Anterior reposition II, includes all cases with gross changes in the bones, which usually take the form of flattening and absorption of the head of the femur, and flattening and condensation of the bone at the site of the upper lip of the acetabulum (Figs 6 and 7) This group includes 14 cases and 17 hips of which 4 cases had a functional end-result of good, 6 rated as fair, and 4 were classified as poor (Table II)

#### CASE REPORTS

The following case reports are of the patients whose roentgenographs were used to illustrate the x-ray classification followed in this group of cases

CASE 9 M M, female, was aged 2 years when first seen in July, 1928 The family history was negative in regard to congenital abnormalities Nothing unusual was noticed about the patient until she began to walk and developed a waddling gait

Examination disclosed a sturdy child who walked with a moderate left limp No lordosis was noted The Trendelenburg sign was positive on the left, telescoping of the left thigh was present and the greater trochanter could be palpated in a superoposterior position Abduction was also limited Roentgenographs made on July 11, 1928, disclosed the left hip to be dislocated superiorly (Fig 1)





Fig. 1. left Case 9. M. M. female aged 4 years. Roentgenogram made in 1939 shows left hip prior to manipulative reduction.



Fig. 2. Roentgenogram made in 1939 shows normal anatomical structure in left hip. Excellent example of class I cure.

the right sustained a greenstick fracture during a remanipulation of the hip. Incidental fractures during the course of treatment included the left tibia and fibula on 2 occasions, a second fracture of the left femur and a fracture of both bones of the left forearm.

An acute streptococcus infection of the throat with an elevation of temperature to 106.4 degrees developed in Case 7 during the 6th month of treatment. The use of antistreptococcus serum produced a rapid subsidence of symptoms, and the infection resulted in no ill effect in regard to the reduced hip. This patient had an excellent end-result when examined 11 years after the reduction.

Diphtheritic symptoms developed in Case 9 during the 2d month after reduction and the child was treated with antidiphtheritic serum. The temperature rapidly declined and the infection produced no undesirable sequelae.



Fig. 3. Case 5. B. B. female aged 5 years at time of manipulative reduction. X-ray film made in 1939 shows anatomical reduction but marked distortion of femoral heads and necks. Class II cure. (The reduction X-ray made in 1923 of too poor quality to reproduce.)

Pneumonia is not an uncommon postoperative complication in all types of surgery and developed in Case 14 during the 7th month after reduction. This case had a poor anatomical end-result although there was no indication in the case record that the hip was involved secondary to the lung infection.

Nerve injury as a complication to reduction was present in only 1 case. A paralytic foot-drop was an immediate complication following reduction in Case 23 but the patient had made a complete recovery when the final plaster was removed 16 months.

Redirection and subluxation are not uncommon occurrences in the course of treatment of the congenital dislocated hip. In the majority of cases, surgical plastic procedures are done, and construction of a shelf over the femoral head is the most frequent plastic operation. Shelving operations were carried out in Cases 13, 9, and 36, at 4, 5, and 10 years after the original reduction respectively.

#### CLASSIFICATION

The 43 cases reviewed in this series, which have been under observation over a period sufficiently long to evaluate with some degree of accuracy the end-result of the congenital misplaced hip after treatment, have been classified both from functional and anatomical findings. Fairbank in 1927 attempted to group his late results of congenital dislocation of the hip and devised an X-ray classification which is simple and yet sufficiently complete to allow a reliable estimate of the results obtained. It is this classification upon which the anatomical findings in the present series are recorded.

The first group in the Fairbank classification (class I cures) includes those cases in which the

activities, he complained of some pain in the left hip at times. The Trendelenburg was positive bilaterally and telescoping was present in the left hip. There was slight limitation of internal rotation and abduction on the left and one inch of shortening. The right hip had full range of motion (Fig. 7).

The technique of Lorenz for reduction of congenital dislocation of the hip has been followed in practically all cases in this series. Although there probably has been some slight modification to suit the individual surgeon, the majority of cases were immobilized following reduction according to the original outline of procedure. The degree of abduction and flexion was at right angles to both planes of the body in almost every instance but the period of immobilization in this position and the other attitudes of less abduction and flexion were entirely dependent upon the stability of the involved hip.

The average period of immobilization in the first or "frog-leg" position was approximately 4 months for all hips treated by the closed method. As this period was of the same duration in the Class I cures as for the other classes, each case was studied for an explanation of the inferior end-results.

Closed reduction which was done after the age of 5 years resulted in unsatisfactory end-results in all cases in this series (Cases 1, 11, 15, 19, and 20). Reduction of the hip was accomplished with difficulty in Case 15, and the hips were not reduced clinically but appeared to be reduced by x-ray in Case 23. The age limit for manipulative reduction is rather low in the opinion of many orthopedists, that is, under the age of 3 or 4 years (Dickson, Fairbank, Putti, Sudbrack, and others), but this procedure is attempted up to the age of 7 or 8 years in numerous clinics. From the undesirable results in the above group of cases, it would appear that the advocates for early reduction have a convincing argument for their opinions. Whether trauma in Case 15 or misleading roentgenograms in Case 23 were responsible for imperfect end-results cannot be definitely determined.

Study of the second group of cases whose end-results left much to be desired disclosed a shorter period of immobilization than the average, but otherwise presented no problem during the course of treatment (Cases 24, 25, 27, 30, and 33). The total period of immobilization averaged 6 months for each case in this group. The presence of very shallow acetabula in Case 24 and sufficient ante-torsion to require osteoclasis in Cases 30 and 33 may also be contributing factors in these 3 cases.

Incomplete reduction or failure to maintain reduction in plaster was noted in 3 cases (Cases 4,

23, and 28). Each case required remanipulation 2 to 7 months after the original reduction. Shallow acetabula were present in each case, and probably the same result would have occurred had a second manipulation not been necessary. Marked instability of the hip due to shallowness of the acetabulum usually requires some plastic operative procedure to correct this condition.

Osteochondritis of the femoral head was noted on the records of Cases 35 and 36 as an explanation of the imperfect results in these patients. No undue force was required at the time of reduction, and the convalescence was uneventful in each case. As to whether osteochondritis is secondary to trauma is a matter of opinion and, although it seems to have a smaller incidence in cases requiring less force in reduction, the condition does occur even though no injury has been inflicted. It has been observed to occur in the apparently normal hip in a case of unilateral misplacement (Oberzimmer, 1933).

Except for 6 cases which offer no reasonable explanation for an undesirable end-result after careful study of the records and roentgenographs (Cases 10, 40, 42, 44, 45, and 47), the remaining cases presented individual problems. Osteogenesis imperfecta congenita was present in Case 3. Multiple fractures prohibited retention of the hips after reduction. In Case 14 pneumonia developed with probable secondary involvement of the congenital hip. In Case 43 there were multiple congenital deformities. The dislocated hip was present in a congenital short extremity. Spina bifida and clubfoot were also present. Postoperative infection developed in Case 48 after a shelving operation for the unstable hip and resulted in gross distortion and redislocation of the femur. Shallow acetabula without operative correction were recorded in Cases 16 and 46 and account for the redislocation in these cases.

#### CONCLUSIONS

Although this series of 48 cases which have been under observation from 7 to 18 years after reduction is rather small to form definite conclusions, it is evident after study of Table II that the group of cases in which patients were treated by closed reduction under the age of 5 years presented late results both clinically and anatomically far superior to those in the older age groups. Also, a period of postreductive immobilization extending over 10 months produced more class I cures in this age group than when a shorter period of plaster fixation was used. Numerous complications have been presented, each of which appears to have a definite bearing upon the final result.



Fig. 6 (left). Case 24, S. H. male, aged 3 years at time of manipulative reduction. X-ray film made in 1930 shows bilateral dislocation of the hips.

Fig. 7. X-ray film made in 1930 shows almost normal anatomical result on the right and distorted (femoral) head above the superior lip of the acetabulum on the left. Left hip is an example of anterior reposition II.

On July 8, 1928, the left hip was manipulated by the Lorenz method under general anesthesia, and the hip was left to reduce with low lead. A bilateral hip spica cast was applied with the hips in a position of 90 degrees of flexion and 90 degrees of abduction. The patient developed symptoms of diphtheria on September 5, 1928, and was treated with antidiphtheritic serum. The original position was maintained until March 1, 1929, when the cast was removed and physical therapy was started. The patient was discharged from the hospital on May 27, 1929, at which time she was walking quite well.

Final examination made on November 5, 1930 disclosed slight flattening of the left buttock. There was no limp and no measurable shortening. The Trendelenburg was negative and full range of motion as present in the hip (Fig. 7).

Case S. B., female, as aged 5 years at the time of the first examination on October 1, 1925. Although the parents noted peculiar gait from the time the child began to walk, nothing was done until the age of 5 years.

Examination on October 3, 1925, disclosed marked adducting gait. There was positive Trendelenburg bilaterally, moderate degree of lordosis, and the trochanters were high. Both hips were free but had some limitation of abduction. The right lower extremity measured one-half inch shorter than the left.

X-ray studies made on the day of examination disclosed dislocation of both hips, the right being higher than the left.

The patient was placed in traction on October 9, 1925 for preanesthetic period. On November 9, 1925 under general anesthesia, both hips were manipulated by the Lorenz method and reduction was accomplished with distinct lead. The hips were immobilized in the frog-leg position and this was maintained until March 20, 1926, when they were placed in second position. The second cast as removed on July 2, 1926. Due to fusion contracture in the left hip, the hip as manipulated under anesthesia on August 6, 1926 and immobilized for 6 weeks. The patient was dismissed from the hospital on January 14, 1927 and still had considerable stiffness in the right hip. A marked right limp as also present.

Final examination made on February 2, 1930, when the patient was 7 years of age and walking full time at school, disclosed practically full range of motion in both hips. There was no shortening nor limp. Both hips were stable (Fig. 8).

Case K. M., female, as aged 5 years, has first examined. The family history as essentially negative. The patient began to walk at the age of 7 months, and an obvious limp was noted. She tended to drag the right leg with each step.

Examination on March 1, 1925 disclosed marked right limp. The right lower extremity measured one-half inch shorter than the left. There was limitation of abduction, and the trochanter as palpated higher than normal.

Röntgenographs made on March 1, 1925 showed the right hip to be dislocated and the left hip to be subluxated (Fig. 4).

The hips were reduced by the Lorenz method on March 8, 1925 and immobilized in the frog-leg position until September 24, 1925 when they were placed in the second position of 75 degrees, less flexion and abduction. The third position was secured on March 30, 1926 and the cast bisected on April 9, 1926.

The last examination as recorded on July 24, 1928, when the patient was 7 years of age. She as complaining of some pain in the right knee after walking. The right buttock was slightly flattened but the hip had full range of motion and was stable. The Trendelenburg as negative but she still had slight limp (There was no measurement noted on the record.) (Fig. 5).

Case 24 S. H., male was aged 5 years, has seen as March 5, 1930. The family history was essentially negative and the patient appeared to be normal until he began to walk. A right limp as noticed by the parents and medical advice was sought soon afterward.

At the time of examination on March 5, 1930, pronounced right limp as noted while walking. There as three-quarters inch shortening of the right lower extremity. Both trochanters were apparently high.

Röntgenograms made on the day of examination disclosed dislocation of both hips (Fig. 6).

On March 27, 1930, under general anesthesia, both hips were manipulated by the Lorenz method but marked instability as found. The hips were immobilized in extreme abduction. The plaster was changed on May 1, 1930 and on May 5, 1930, and the hips placed in lateral rotation, abduction, and extension. A bilateral manual osteotomy in the supracondylar region of femur as done on July 10, 1930. The plaster as removed about 3 months later.

Final examination on April 6, 1930, 5 years after reduction, disclosed well developed male who walked with left limp. Although he was able to engage in all types of

# THE SURGICAL TREATMENT OF BRONCHIECTASIS

## A Report on 76 Patients

HOWARD H. BRADSHAW, M.D., F.A.C.S., and JAMES F. O'NEILL, M.D.,  
Winston-Salem, North Carolina

MANY excellent papers have been published in recent years on the subject of the surgical treatment of bronchiectasis and considerable data have accumulated. The immediate mortality has been steadily lowered and the indications for operation are being broadened constantly. Many of the details of operation have been emphasized by Churchill (4), Edwards, Haight, Blades (1), and others. The normal and abnormal surgical anatomy concerned with the operation has been portrayed by Churchill and Belsey (5), Kent and Blades (9, 10), so that it can be said that the operation has become more or less standardized. It is apparent that in the presence of conventional anatomy, lobectomy for unilobar bronchiectasis is a relatively simple operation and carries with it a mortality of not more than 1 or 2 per cent. However, with a more careful iodized oil study of the bronchial system, it is evident that simple unilobar bronchiectasis is not usually encountered. Indeed it seems more likely that many, if not most cases of unilobar bronchiectasis have resulted from the presence of a foreign body or some other form of partial or complete bronchial obstruction. A careful review of the case histories of many patients with unilobar bronchiectasis tends to support such a belief.

More and more patients with bilateral disease are being subjected to bilateral lobectomy with considerable success (Eloesser, Lewis, Overholt, Bradshaw and Chodoff, Blades and Graham). Several patients have had three and a part of a fourth lobe removed successfully. The operative mortality in this group of patients is, of course, much higher than in the unilobar group. It is difficult to obtain exact figures, but the mortality is in the neighborhood of 15 per cent. The mortality in untreated bronchiectasis is about 35 per cent in patients that have been studied to date (Perry and King, Bradshaw, Putney and Clerf). However, it is probable that many more of these patients will die from bronchiectasis or its complications if they are observed for a longer period of time.

In a discussion of the mortality of operation for bronchiectasis, it seems desirable to include only those patients with no known cause for their bronchiectasis. As a rule in most reports, all operations for bronchiectasis have been grouped together regardless of the probable underlying cause. The changes produced in the thorax as a result of pulmonary abscesses or as a result of a more or less complete bronchial obstruction from tuberculous infection may be very different from those produced by the usual type of bronchiectasis. The amount of dissection required in bronchiectasis resulting from abscesses and the lack of healing often exhibited after the removal of a lobe in the presence of tuberculous involvement, may and frequently does increase the mortality of operation. An attempt has been made in the present report to include only the operations on patients with bronchiectasis resulting from no known etiological agent or agents.

The complication which most often leads to a fatality after lobectomy is infection. Since the operation is usually done as an elective procedure, time should be utilized in getting these patients in the best possible physical condition by means of postural drainage, or repeated bronchoscopies or both, the removal of all accessible areas of infection such as in the paranasal sinuses and teeth, a high vitamin and high caloric intake, and blood transfusions. The use of a sulfonamide before operation has certain advantages as well as some disadvantages. These are well known and need no elaboration here. In this series of cases, some patients have been given a sulfonamide and others have not. There certainly has been no striking difference in recovery in either group. Perhaps more experience will lend evidence one way or the other. If obvious acute respiratory infection is present either in the patient or in the individuals with whom he will come in contact during his hospital stay, the operation should be postponed. The operation should be postponed for at least 6 weeks following the injection of iodized oil.

In the majority of patients in this series, the operation has been carried out under endotracheal oxygen-ether anesthesia. The usual procedure is to give a small dose,  $\frac{1}{2}$  grain, of sodium pheno-

From the Jefferson Hospital Philadelphia and the Bowman Gray School of Medicine Winston-Salem

In a few cases the clinical result was surprising  
ly superior to the anatomical findings, but as a  
rule, the more nearly normal the joint appeared  
the better was the clinical result.

## REFERENCES

- BONE, MAX. *Zachr orthop. Chir* 93 3 566
1. COOPER, G. K., and STEWART WILKINSON. *J Bone Surg* 934, 6 303
2. DEER, W. *Chir org monbn.* 933, 8 425.
4. DICKSON, F. D. *Surg Gyn Obst* 934, 33 81.
5. FAIRBANK, H. A. T. *Brit. J Surg* 930, 7 570.
6. Idem. *Brit. M. J* 930, 607
7. Idem. *Brit. J Surg* 9 2, 24.
8. OBERLINNICKER, J. *Chir org. monbn.* 933, 8 31
9. PUTTI, V. *Arch. ital. chir* 937 3 1.
10. Idem. *Chir org monbn.* 934, 93.
- PUTTI, V. and ZANOLI, R. *Chir org monbn* 1934, 6
11. STEINER, RICHARDSON. *J Bone Surg* 438, 10 515
12. STERNACK, J. *Zachr orthop. Chir* 938, 90-9
14. TIERCE, A. H. *Deformities Including Diseases of the Bones and Joints* London MacMillan and Co., 912.

# THE SURGICAL TREATMENT OF BRONCHIECTASIS

## A Report on 76 Patients

HOWARD H BRADSHAW, M D, F A C S, and JAMES F O NEILL, M D,  
Winston-Salem, North Carolina

MANY excellent papers have been published in recent years on the subject of the surgical treatment of bronchiectasis and considerable data have accumulated. The immediate mortality has been steadily lowered and the indications for operation are being broadened constantly. Many of the details of operation have been emphasized by Churchill (4), Edwards, Haight, Blades (1), and others. The normal and abnormal surgical anatomy concerned with the operation has been portrayed by Churchill and Belsey (5), Kent and Blades (9, 10), so that it can be said that the operation has become more or less standardized. It is apparent that in the presence of conventional anatomy, lobectomy for unilateral bronchiectasis is a relatively simple operation and carries with it a mortality of not more than 1 or 2 per cent. However, with a more careful iodized oil study of the bronchial system, it is evident that simple unilateral bronchiectasis is not usually encountered. Indeed it seems more likely that many, if not most cases of unilateral bronchiectasis have resulted from the presence of a foreign body or some other form of partial or complete bronchial obstruction. A careful review of the case histories of many patients with unilateral bronchiectasis tends to support such a belief.

More and more patients with bilateral disease are being subjected to bilateral lobectomy with considerable success (Eloesser, Lewis, Overholt, Bradshaw and Chodoff, Blades and Graham). Several patients have had three and a part of a fourth lobe removed successfully. The operative mortality in this group of patients is, of course, much higher than in the unilateral group. It is difficult to obtain exact figures, but the mortality is in the neighborhood of 15 per cent. The mortality in untreated bronchiectasis is about 35 per cent in patients that have been studied to date (Perry and King, Bradshaw, Putney and Clerf). However, it is probable that many more of these patients will die from bronchiectasis or its complications if they are observed for a longer period of time.

In a discussion of the mortality of operation for bronchiectasis, it seems desirable to include only those patients with no known cause for their bronchiectasis. As a rule in most reports, all operations for bronchiectasis have been grouped together regardless of the probable underlying cause. The changes produced in the thorax as a result of pulmonary abscesses or as a result of a more or less complete bronchial obstruction from tuberculous infection may be very different from those produced by the usual type of bronchiectasis. The amount of dissection required in bronchiectasis resulting from abscesses and the lack of healing often exhibited after the removal of a lobe in the presence of tuberculous involvement, may and frequently does increase the mortality of operation. An attempt has been made in the present report to include only the operations on patients with bronchiectasis resulting from no known etiological agent or agents.

The complication which most often leads to a fatality after lobectomy is infection. Since the operation is usually done as an elective procedure, time should be utilized in getting these patients in the best possible physical condition by means of postural drainage, or repeated bronchoscopies or both, the removal of all accessible areas of infection such as in the paranasal sinuses and teeth, a high vitamin and high caloric intake, and blood transfusions. The use of a sulfonamide before operation has certain advantages as well as some disadvantages. These are well known and need no elaboration here. In this series of cases, some patients have been given a sulfonamide and others have not. There certainly has been no striking difference in recovery in either group. Perhaps more experience will lend evidence one way or the other. If obvious acute respiratory infection is present either in the patient or in the individuals with whom he will come in contact during his hospital stay, the operation should be postponed. The operation should be postponed for at least 6 weeks following the injection of iodized oil.

In the majority of patients in this series, the operation has been carried out under endotracheal oxygen-ether anesthesia. The usual procedure is to give a small dose,  $\frac{1}{2}$  grain, of sodium pheno-

barbital the night before operation. The following day 3 hours before operating time, 1½ grains of nembutal is given and 1 hour before operation, if needed, 1½ grains of nembutal, 1/150 grain of scopolamine and 1/6 grain of morphine are given. (Cyclopropane and oxygen are used for induction and for the introduction of the endotracheal tube.) Ether is gradually added as the cyclopropane is withdrawn. When the proper level of oxygen-ether anesthesia is reached, the tracheobronchial system is thoroughly aspirated by passing a small catheter through the endotracheal tube. The tube is allowed to project about 1 inch above the level of the lips and a face mask is fitted snugly over all. The oxygen-ether anesthesia is continued throughout the operation. Aspiration can be easily repeated at any time during the operation and should be thoroughly done at the close of the operation before the tube has been removed. If this is properly done it obviates the necessity for bronchoscopic or other aspiration, at least for a few hours. A few lobectomies and pneumonectomies have been done under continuous spinal anesthesia because of the obvious advantage it presents in allowing the use of a coagulating electrode. Chest wall bleeding in the presence of many adhesions is difficult to control by ordinary ligation or suture-ligation methods. A cautery affords the best means for control, but it is of course dangerous in the presence of an explosive anesthetic mixture. The patients under continuous spinal anesthesia have not been entirely comfortable unless rather large doses of morphine and scopolamine are given at intervals throughout the operative procedure. The cough reflex may be active despite the infiltration of hilar structures with per cent novocain solution. This is troublesome when the pulmonary vessels are being ligated and the bronchus is being sutured. It would be highly desirable if this or some other method were developed which permits the safe use of cautery inside the thorax.

It is ideal if at all possible, to ligate individually the vessels and the bronchus of the hilum of the lobe. This permits the removal of greater length of the bronchus. The older method of mass ligation of the hilum was not a clean-cut procedure and left a mass of tissue to become necrotic and slough into the pleural cavity. This undoubtedly contributed to if it did not actually cause, many of the extensive postoperative emphysemas. Unfortunately it is not always possible to do individual ligations because of extensive disease which causes such dense matting together of the vessels and bronchus that their dissection would be hazardous. Enlarged, adherent lymph nodes

may make it impossible to bare the structures for individual ligation. Under such circumstances, it is often possible to ligate the inferior pulmonary vein to the lobe, divide it, and then apply a lobe tourniquet. This manipulation aids considerably in the production of a small stump. It should be emphasized that it is unwise to persist in attempts at individual ligations in the face of a disease process which makes separation of the structure unlikely or impossible. The hilum should be properly exposed and the possibility of individual ligation quickly determined before a long tedious dissection is undertaken that may have to be abandoned in favor of mass ligation.

If the fissures between lobes were always complete and if the structures of the hilum were always easily separable pulmonary lobectomy would be a relatively simple operation unfortunately that is rarely the case. It is sometimes possible by temporarily occluding a lobe bronchus and slightly overinflating the surrounding lobes to find a line of demarcation which can be carefully dissected and not produce bleeding from either lobe. This is not often possible if the fissure has not been present at one time. Frequently the vascular and bronchial systems between parts of lobes communicate freely with each other. Many clamps have been devised for controlling hemorrhage during the separation of the lobes, but none has proved to be satisfactory. It is fairly efficient to start two running lock stitch sutures of fine chromicized gut to control the hemorrhage as the formation of the fissure begins. If the sutures keep pace with the dissection, very little blood is lost. Mattress sutures of fine silk can be used to bring pleural surfaces together over the raw area of the lobes. During the last 3 years, after the lobe has been removed and all bleeding controlled, sulfanilamide has been dusted on the hilar region. Formerly intercostal tube drainage was used in all patients for a number of days. It became evident that shorter periods of drainage are adequate in patients that had little sputum, had not had bouts of pneumonitis, and had had clean cut removal of the lobe with a very small stump remaining and no obvious soiling of the pleura. Under these conditions the tube remained in place until the pneumothorax has been removed, the lung re-expanded and the drainage was small in amount and contained a few or no organisms. Frequently the tube was removed within 48 hours. With the advent of sulfanilamide apparently occasional patient will need no drainage at all. It is likely that some of this latter group of patients will need drainage of a residual empyema. Certainly the period of hospitalization is shortened

by weeks if no drainage is required. A report on all patients that have been closed without drainage should be made from time to time to determine whether or not such a plan is desirable in the majority of patients. The economic loss to hospitals by the prolonged stay of patients who have been drained is considerable, and anything which will safely allow the earlier discharge of them should be encouraged.

In a discussion of the mortality from operations for bronchiectasis it is essential to know just the type and extent of the disease under discussion. As has been indicated, so called primary bronchiectasis carries with it a considerably lower mortality than does bronchiectasis secondary to abscesses and tuberculous infections. Furthermore, the extent of the disease influences the outcome. In a report on this disease, therefore, it is desirable to indicate clearly the nature and extent of the disease rather than to discuss, without qualifying it, the mortality following lobectomy for bronchiectasis. The feasibility of the operation has been unquestionably established. During the early stages of development of the operation, it was necessary to be extremely careful in the selection of cases to prevent its falling into disrepute. But with the high mortality which is known to occur in untreated patients and with the chronic invalidism present in those that do not die, it is logical to extend indications for operations to the fullest extent. This is being done in many clinics. The philosophy of the operating surgeon is a most important factor. The general policy of the authors has been to refuse to operate only on elderly patients with bilateral disease.

The results in 76 patients operated upon for primary bronchiectasis, in so far as the clinical history and findings permitted such a diagnosis to be made, are as follows:

1 Twenty-four patients with lower lobe or lower lobe and lingula disease were operated upon with 1 death, a mortality of 4.2 per cent. All obviously diseased lung tissue was removed.

2 Twenty-six patients had one lobe removed but disease was present in other lobes with 4 deaths, a mortality rate of 15.4 per cent.

3 Seventeen patients had 2 or more lobes removed with 3 deaths, a mortality of 18 per cent. Eleven had disease in other lobes.

4 Pneumonectomy was performed on 9 patients with 4 deaths, a mortality of 44 per cent. Disease was present in the remaining lung in all the patients who died.

From these results certain facts seem clear. With minimal disease that can be completely removed, the results are excellent. One death that

occurred in this group was due to an error in judgment. In this patient, attempts at dissection lobectomy should have been abandoned and resort had to the cautery. If disease is present in many lobes, the most diseased lobe can be removed with relative safety but the mortality is probably 3 to 4 times as great as it is in single lobe and lingula disease. Multiple lobes can be removed in the presence of disease in remaining lobes with only a slightly greater mortality than occurred in single lobe removals in the presence of disease in some of the remaining lobes. Pneumonectomy can be safely done if the disease is limited to the side that is removed. Although the present series of pneumonectomies is not great enough to be significant, the results when disease is present in the contralateral lung, do not seem to justify the procedure.

The extent and type of bronchiectasis play an important part in the difficulty of operation and the subsequent mortality. Certainly minimal cylindrical changes in a lobe are not as serious as large saccular dilatations. In these 76 patients, when a lobe has been called "diseased" it means that there is definite evidence of bronchiectasis by iodized oil studies. Those lobes whose bronchi appear to be only "top normal" in size are not considered in this analysis.

The causes of death in the 12 patients that died are as follows: (1) Four patients had flooding of the remaining bronchi with pus despite frequent bronchoscopies or continuous endobronchial suction drainage. One 5 year old boy also had a 60 gram thymus. (2) Two had bilateral pneumonia or pneumonitis. (3) Cerebral abscesses developed in 2 patients. (4) Thyroid and hepatic abscesses were present. (5) Septicemia, pericarditis, and perforated duodenal ulcer were present. (6) Abscesses were noted in opposite lung. (7) Hemorrhage from inferior pulmonary vein.

#### SUMMARY AND CONCLUSIONS

1 An analysis has been made of the results in 76 patients who have been operated upon for so called primary bronchiectasis. These patients represent an attempt to care for the routine admissions to the hospital and were not selected with the view of establishing any kind of record.

2 The mortality in patients with untreated bronchiectasis is 35 per cent to date.

3 The mortality in patients that have been operated upon for minimal bronchiectasis is 4 per cent or less.

4 The mortality in patients who have been operated upon for extensive bilateral disease is 44 per cent.



barbital the night before operation. The following day 2 hours before operating time  $1\frac{1}{2}$  grains of nembutal is given and 1 hour before operation if needed  $1\frac{1}{2}$  grains of nembutal,  $1/150$  grain of scopolamine, and  $1/6$  grain of morphine are given. (Cyclopropane and oxygen are used for induction and the production of the endotracheal tube.) Ether is gradually added as the cyclopropane is withdrawn. When the proper level of oxygen-ether anesthesia is reached, the tracheobronchial system is thoroughly aspirated by passing a small catheter through the endotracheal tube. The tube is allowed to project about 1 inch above the level of the lips and a face mask is fitted snugly over all. The oxygen-ether anesthesia is continued throughout the operation. Aspiration can be easily repeated at any time during the operation and should be thoroughly done at the close of the operation before the tube has been removed. If this is properly done it obviates the necessity for bronchoscopic or other aspiration at least for a few hours. A few lobectomies and pneumonectomies have been done under continuous spinal anesthesia because of the obvious advantage it presents in allowing the use of a coagulating electrode. Chest wall bleeding in the presence of many adhesions is difficult to control by ordinary ligature suture-ligature methods. A cautery affords the best means for control, but it is of course dangerous in the presence of an explosive anesthetic mixture. The patients under continuous spinal anesthesia have not been entirely comfortable unless rather large doses of morphine and scopolamine are given at intervals throughout the operative procedure. The cough reflex may be active despite the infiltration of hilar structures with 1 per cent novocain solution. This is troublesome when the pulmonary vessels are being ligated and the bronchus is being sutured. It would be highly desirable if this or some other method were developed which permits the safe use of cauterizers inside the thorax.

It is ideal if at all possible, to ligate individually the vessels and the bronchus of the hilum of the lobe. This permits the removal of a greater length of the bronchus. The older method of mass ligation of the hilum was not a clean-cut procedure and left a mass of tissue that became necrotic and slough into the pleural cavity. This undoubtedly contributed to, if it did not actually cause, many of the extensive postoperative empyemas. Unfortunately it is not always possible to do individual ligations because of extensive disease which causes such a dense matting together of the vessels and bronchus that their dissection would be hazardous. Enlarged, adherent lymph nodes

may make it impossible to bare the structures for individual ligation. Under such circumstances, it is often possible to ligate the inferior pulmonary vein to the lobe, divide it, and then apply a lobe tourniquet. This manipulation aids considerably in the production of a small stump. It should be emphasized that it is unwise to persist in attempts at individual ligations in the face of a disease process which makes separation of the structure unlikely or impossible. The hilum should be properly exposed and the possibility of individual ligation quickly determined before a long tedious dissection is undertaken that may have to be abandoned in favor of mass ligation.

If the fissures between lobes were always complete and if the structures of the hilum were always easily separable pulmonary lobectomies would be a relatively simple operation unfortunately that is rarely the case. It is sometimes possible by temporarily occluding a lobe bronchus and slightly overinflating the surrounding lobes to find a line of demarcation which can be carefully dissected and not produce bleeding from either lobe. This is not often possible if the fissure has not been present at one time. Frequently the vascular and bronchial systems between parts of lobes communicate freely with each other. Many clamps have been devised for controlling hemorrhage during the separation of the lobes, but none has proved to be satisfactory. It is fairly efficient to start two running lock stitch sutures of a fine chromicized gut to control the hemorrhage as the formation of the fissure begins. If the sutures keep pace with the dissection, very little blood is lost. Mitres sutures of fine silk can be used to bring pleural surfaces together over the raw area of the lobes. During the last 3 years, after the lobe has been removed and all bleeding controlled, sulfanilamide has been dusted on the hilar region. Intermittent intercostal tube drainage was used in all patients for a number of days. It became evident that shorter periods of drainage were adequate in patients that had little sputum, had not had bouts of pneumonia, and had had a clean cut removal of the lobe with a very small stump remaining and no obvious soiling of the pleura. Under these conditions the tube remained in place until the pneumothorax has been removed, the lung re-expanded and the drainage was small in amount and contained a few or no organisms. Frequently the tube was removed within 48 hours. With the advent of sulfanilamide apparently an occasional patient still need no drainage at all. It is likely that some of this latter group of patients will need drainage of a residual empyema. Certainly the period of hospitalization is shortened

# OMPHALOCELE

## Anatomical and Clinical Considerations

NORMAN W. SPECHT, M.D., and E. HAROLD SHRYOCK, M.D., Loma Linda, California

**O**MPHALOCELE is a rare condition in which various abdominal viscera are found at birth in the base of the umbilical cord. Omphalocele may be differentiated from ordinary umbilical hernia by the observation that the covering of the former consists of two avascular fused membranes, amnion and peritoneum, whereas the covering of the latter consists of skin.

As pointed out by Clagett and Dixon, there has been considerable confusion in the literature regarding the name of this anomaly. Omphalocele, eventration, congenital umbilical hernia, hernia into the umbilical cord, amniotic hernia, funicular hernia of the umbilicus, and exomphalos have been used synonymously. The authors prefer the term omphalocele which term is sufficiently descriptive to differentiate the condition from postnatal umbilical hernia.

### INCIDENCE

Since the report of the first case in 1634 about 400 cases have been recorded, nearly half of these since 1900. The incidence has been variously estimated, the usual figures being 1 to every 5,000 or 6,000 infants. This incidence implies that many cases have occurred which have not been reported.

Less severe forms in which only portions of the intestinal tract are included in the sac are twice as common as those in which the liver, gall bladder, and spleen are also present. There seems to be a predilection for the male sex, only half as many being present in females.

### EMBRYOLOGY

In order to understand the mechanism of the production of omphalocele a brief review of the embryology of the digestive tract is in order.

Up to 4 weeks of development, the digestive tract resembles a straight tube. Attached to it ventrally is the yolk stalk or vitelline duct which extends through the umbilical aperture into the umbilical cord. The gut tract, below that portion destined to be stomach, possesses no ventral mesentery but is attached only to the dorsal body wall by the dorsal mesentery. The superior mesen-

teric artery runs through the dorsal mesentery to supply the gut in the vicinity of the yolk stalk.

Beginning with the second month, the relative rate of growth of the intestine and liver is more rapid than that of the tissues bounding the celomic cavity. To relieve the resultant crowding of the viscera there develops a ventral extension of the peritoneal cavity into the base of the umbilical cord. This space is normally occupied by those portions of the intestine which are adjacent to the site of attachment of the yolk stalk and which are supplied by the superior mesenteric artery. There is thus formed a so called physiological umbilical hernia.

When the gut first herniates into the base of the umbilical cord, it consists of a single loop with the yolk stalk attached at the bend of the loop, the loop being in the sagittal plane. Rotation of the gut begins soon after the establishment of the hernia. According to Dott's classical description, the rotation of the gut occurs in three stages.

*First stage.* The first stage of rotation takes place between the 5th and 10th weeks of intra-uterine life. It consists of a counterclockwise rotation (when the specimen is viewed from in front) of the loop of gut which occupies the umbilical hernia with the superior mesenteric artery serving as the axis of rotation. The rotation continues through more than 180 degrees or until the cephalic limb of the loop lies beneath and to the fetus' left of the caudal limb. It is during this stage that atrophy of the yolk stalk normally occurs.

*Second stage.* At the onset of the second stage the development of the abdominal cavity has overtaken that of the viscera, and the intestinal tract is withdrawn into the abdomen. For reasons that are not positively understood, the cephalic portion of the loop is withdrawn first. As this cephalic portion is withdrawn from the hernial sac, it lies behind the superior mesenteric artery and occupies the central portion of the general peritoneal cavity. This crowds the unherniated portion of the colon to the left. The return of the caudal portion of the herniated gut to the general peritoneal cavity constitutes the final phase of the second stage of rotation and occurs at about the 11th week.

From the Department of Microscopic Anatomy, College of Medical Evangelists.

5. The technical difficulties of pulmonary lobectomy are emphasized.

6. The causes of death in patients who have been operated upon for bronchiectasis are tabulated.

#### REFERENCES

- BLADEN, B. *Surgery* 940, 8 79-754
1. BLADEN, B. and GEARMAN, E. A. *Surg. Gyn. Obst.* 942, 73 457-464
2. BRADSHAW H. H., and CROGDON R. J. *Surgery* 930, 3 593
3. CRITCHFIELD, E. D. *J. Thorac. Surg.* 931, 4 144-31
4. CRITCHFIELD, E. D. and BELSKY R. *Ann. Surg.* 1939, 69, 4 499
5. EDWARDS, J. T. *Brit. M. J.* 930, 309-3
6. FLORENCE, L. *Surg. Gyn. Obst.* 933, 57 147-149
7. HART, C. T. *West. Surg. Ass.* 933, 46 170-91
8. KENT, E. M., and BLADEN, B. *J. Thorac. Surg.* 1933, 4-30
9. LEWIS, A. *Surg.* 922, 6 712-795
10. LEWIS, *Brit. J. Surg.* 930, 24 362-367
11. OVERHOL, R. H. *J. Am. M. Ass.* 937, 99 23



Fig 1 Photograph of infant in Case 1, before operation, showing the relation of the omphalocele to the umbilical cord and to the body wall

mipara, one abortion) Some difficulty was encountered in delivering the abdomen because of the large omphalocele. The cry was spontaneous but weak. The omphalocele consisted of a mass (10 by 10 by 5 cm) enveloped by a transparent membrane. The orifice connecting the sac with the abdominal cavity was about 5 centimeters in diameter. The cord was attached 4 centimeters from the skin margin. The infant also presented cryptorchidism.

In spite of the large sac, surgery was begun 7½ hours after delivery under open drop ether anesthesia. Oxygen was given throughout the operation. It was found that the liver, spleen, and intestine were contained in the sac. The liver was firmly adherent to the anterior portion of the sac. The midgut had not rotated and the abdominal cavity was not well developed. Since the hernial contents could be only partially reduced by compression, the neck of the sac was split upward and downward through the abdominal wall. Finally, when the hernial contents had been reduced as far as possible, the liver occupied the entire right side of the abdomen, and the intestine and spleen the left side. The abdominal wall was closed with interrupted heavy black silk sutures for the most part bringing only the skin together. In spite of the administration of continuous oxygen and several stimulants the infant expired 10 hours after surgery.

CASE 4. This infant was delivered at 8 lunar months from a primigravida. Both parents were in good health. The mother's prenatal course was uneventful except for a troublesome vaginal discharge, the cause of which could not be determined. After a somewhat lengthened labor, birth was spontaneous. No difficulty was encountered in delivering the infant's abdomen. At birth the fetal heart was still heard. The baby gasped several times but lived only a few minutes.

Practically the entire anterior abdominal wall was absent (Fig 3). A large mass 7 by 6 by 6 centimeters protruded forward beyond the usual location of the abdominal wall. A translucent membrane covered the mass and was attached to the skin, on either side, at the lateral abdominal wall, above, to the skin at the lower rib margins, and, below, to the skin over the symphysis pubis. The membrane forming the sac was very much thickened and opaque in its lower third and was thrown into numerous large and small folds. The hernial mass contained the entire liver, gall bladder, spleen, stomach, and the intestine. The liver occupied the left upper portion of the mass. Its superior surface was adherent to the covering membrane. The umbilical vein entered the lower aspect of the liver. The duodenum was not retroperitoneal but possessed a mesentery and was freely movable. No ileocecal junction or vermiform appendix could be identified. The intestine was collapsed and could be followed through its many coils until it opened externally through that part of the thick membrane which covered the lower portion of the hernial mass. About 2 centimeters below this opening there appeared a second opening into a blind sac which measured 1 centimeter in diameter. The area of the covering membrane between these two openings was thrown into numerous folds or trabeculae. Histological study of this membrane showed its structure to be that of large intestine. The position of the intestinal tract was typical of nonrotation. The kidneys were in normal position. The ureters were dilated and terminated in the covering of the hernial sac below the site of the intestinal orifices. Sections taken from the region of the urethral orifices showed transitional epithelium. This was the only clue as to the presence or absence of a urinary bladder. The abdominal cavity was almost entirely occupied by the vertebral column. The

There is a lack of general agreement as to the factors which cause the reduction of the physiological umbilical hernia. It is conceded that one or more of the following factors may be responsible: (1) a negative intra-abdominal pressure produced by a relative retardation in the rate of growth of the liver; (2) positive extra-abdominal pressure; (3) traction exerted by the mesentery because of a relative retardation of its rate of growth; (4) tension exerted by the nonherniated portions of the gut. (Ball, after studying pig embryos, suggested that an increase in the number of intra-abdominal loops of the intestine and their rotation may draw upon the herniated portion.) (5) pressure exerted against the inferior portion of the hernia because of enlargement of the umbilical arteries.

In the normal course of events the return of the intestine to the abdominal cavity is promptly followed by an obliteration of the sac of the umbilical hernia.

**Third stage.** This stage is characterized by the descent of the cecum into the right lower abdominal quadrant and the fixation of the duodenum and portions of the colon to the posterior abdominal wall. This stage extends from the 11th week until birth or shortly after.

Anomalies in rotation may take place in any one of the three stages. Most commonly they occur in either the second or third stage. According to Dott, anomalies in rotation are 3 times more common in males than in females.

#### ETIOLOGY

Many suggestions have been made as to the cause of omphalocele. Thus much is certain that anything which hinders or prevents the normal return of the intestine to the abdominal cavity must be considered a possible cause. Alfich, quoting various authors, suggested the following factors: persistence of the fetal convexity of the dorsal spine, arrest in the development of the primitive vertebrae and the abdominal walls, persistence of the yolk stalk, and the presence of fetal peritonitis. The most commonly accepted explanation is that there exists a disproportion between the abdominal viscera and the abdominal cavity. This disproportion usually results from retarded development of the abdominal parietes. This factor may become active during the second stage of rotation of the gut or it may develop later so that the liver or other organs herniate through an umbilical aperture that has not been obliterated.

Although most of the cases can thus be interpreted there are still some that defy explanation. Among these are some in which most of the an-

terior abdominal wall consists of a transparent membrane. Thunig speaks of this condition as amniotic linea alba.

#### REPORT OF CASES

**CASE 1.** The mother of this infant, a 30 year old multipara who had borne previous children, both of which are living and well. She had been in good health except for chronic eye complaint and for Trichomonas vaginalis infection the previous year. The latter readily cleared up under treatment. No complication of pregnancy as noted aside from ankle edema. The infant (male) as born at home spontaneously at term following normal labor. Cry as immediate and vigorous. Except for the omphalocele, the infant as in good health. Tars failed to reduce the hernial mass. In fact it grew larger with each cry. Upon hospitalization the protruding mass appeared as Figure 1.

When the sac as opened, surgery it was found to contain approximately the low or half of the ileum, the cecum and at least portion of the ascending colon. A Meckel's diverticulum as noted. After the intestine as freed from the sac and returned to the abdomen, the cord was doubly ligated. The peritoneum as closed and the rectus muscles as approximated with chronic catgut suture. After bringing together the subcutaneous tissue with plain catgut, the skin as sutured with silk.

The surgery as completed under local anesthesia within 65 hours following birth. The infant as discharged from the hospital on the 10th day after an uneventful postoperative course.

At the time of writing, the child is more than 3½ years of age and there is no apparent calcareous in the exterior abdominal wall (Fig. 2). Recent roentgenographic examination of the intestinal tract has shown no malposition of the intestinal tract. Neither could Meckel's diverticulum be demonstrated.

**CASE 2.** The mother in Case 2, a 33 year old Japanese multipara (secundipara, trigravida) 50 years history of having had tuberculous 3½ years previously (arrested). The infant (female) as delivered in good condition except for large omphalocele. Several lactogen feedings are given prior to operation. Surgery was done under ether anesthesia 50 hours after delivery. The hernial sac showed some evidences of calcareous by the time of operation. The sac contained the liver, spleen, stomach, and intestine. The abdomen as poorly developed and obviously inadequate to accommodate the usual structures. Partial reduction of the mass as accomplished by taxis and opening of the sac. The liver was firmly adherent to the entire superior portion. The mesentery, as poorly developed. After the viscera were freed and placed in the abdominal cavity it was found that the arteries could not be approximated. Closure as accomplished by suturing together the skin margins, with the sac of interrupted silk as described by Ladd.

The prognosis immediately after operation as considered to be poor. For the first week after operation the infant as given lactated Ringer's solution subcutaneously several times daily and frequent carbogen inhalations. Three small stools are passed on the day of surgery. Feedings by mouth began the second postoperative day. After 6 days the temperature remained normal and the infant as discharged in 3 weeks in good condition.

**CASE 3.** A 4½ mile infant as delivered spontaneously at term from a 35 year old multipara (trigravida, 3rd).

Dr. James W. Brown, Floyd E. and J. Vernon Nichols, and Thomas I. Zerkle were most helpful in making available cases and case records and Dr. Lelia R. Simpson for her roentgenographic studies.

out by Ladd and Gross, the size of the sac bears no direct relation to the size of the defect in the abdominal wall. The skin usually stops at the base of the sac or continues onto it for only a short distance.

Most authors emphasize the character of the sac. At delivery it is soft and pliable, but because of its poor blood supply it soon becomes opaque, dry, friable, and even necrotic. Jarcho collected 27 cases in which the sac was completely absent, torn, or consisted of remnants. Krumm mentioned a case in which the sac was completely absent as in Case 5 of the present series. Although the sac may rupture under the stress of labor, Jarcho noted that an omphalocele rarely causes difficulty at the time of delivery because the mass is soft and somewhat movable. One of the two patients operated upon by O'Leary and Clymer survived a tear in the membrane bounding the omphalocele. Klopp reported a case in which hemorrhage took place from torn umbilical vessels.

Usually the diagnosis of omphalocele is obvious and immediately recognized by the obstetrician. A warning should nevertheless be given regarding those very mild cases in which only a small loop of intestine is present in the cord. Clamping and ligating the intestine with the cord will, of course, produce intestinal obstruction. Even though recognized soon after ligation a fistula will result.

Practically all authors stress the frequency of associated anomalies. In the 5 cases described herein, all but 1 were known to have presented other anomalies. Although the incidence of persistent yolk stalk is higher in cases with omphalocele than in the general run of cases, it cannot be assumed that the persistent yolk stalk is necessarily responsible for the development of the omphalocele. In this connection it is interesting to note that the case reported by Niebuhr, Dresch, and Logan presented an omphalocele which contained no portion of the intestine.

Infants with omphalocele present no symptoms until several hours after delivery. Inasmuch as the umbilical aperture is usually large, obstruction or strangulation seldom occurs. Symptoms, when they do appear, depend upon the development of necrosis of the sac of the omphalocele, infection, or actual peritonitis. Early surgical treatment is imperative.

It is possible that there has been an overemphasis of the etiological significance of concavity of the fetal spine which has been observed in some cases of omphalocele. In the present series, the infant in Case 4 was the only one in which the deformed vertebral column might have contributed to the development of the omphalocele.



Fig. 3 Photograph of infant in Case 4, showing the extensive defect in the anterior abdominal wall.

Searle and Ingmire have called attention to the possibility that a disproportion of the maternal pelvis may increase the curvature of the fetal back, thus preventing extension of the abdominal cavity so as to leave no space for the abdominal organs. If such a factor were active in every case of omphalocele, it would seem that there should be repeated instances of omphaloceles occurring in the children of one family. Most authors agree, however, that there is no familial tendency.

Along with an omphalocele, the infant in Case 4 presented what Dott described as extroversion of the cloaca. "In this condition the ureters, genital ducts, and intestinal canal all open on the extroverted area. The ileum usually opens on the surface, and the large intestine is represented only by histological remnants on the extroverted area. A very short intra-abdominal portion of the large bowel may be present."

#### TREATMENT

Inasmuch as in untreated cases of omphalocele the covering sac soon becomes desiccated and peritonitis ensues, prompt treatment is imperative. Jarcho, in his summary of the various methods of treating omphalocele, concludes that



Fig. Photograph of child in Case 1 at the age of  $3\frac{1}{2}$  years.

innominate bones instead of being fused anteriorly were widely separated. The following additional anomalies were also noted: undifferentiated external genitalia, bilateral cryptorchidism, infantile type of concretion of the aorta, single umbilical artery, spina bifida occulta, clubbing of the 2d and 3d toes on each foot, and right clubfoot.

Case 3. The mother in this case, a 37-year-old late primipara, was in good health. Her prenatal course was normal and uneventful except for frequent vomiting during the first 4 months. After 9 hours of labor she spontaneously delivered an 8 $\frac{3}{4}$  lunar month stillborn premature female. Never were the fetal heart tones heard during labor.

The infant (Fig. 4) weighed 3 pounds and 3 ounces and measured 4 centimeters in length. The most obvious deformity was the large mass of organs lying on the anterior abdominal wall, even extending up over the chest. The mass, measuring 9 centimeters in size and composed of liver, spleen, stomach, and both large and small intestines. This mass had no covering nor could the remnants of one be found. These organs were connected with those inside the abdomen through an opening 3.5 by 3 centimeters in the center of the anterior abdominal wall. The liver occupied the right upper portion of the mass and the spleen the left. The large intestine was entirely on the left side, the small intestine above and between the liver and colon. The entire liver was outside of the abdomen. The gall bladder was found within the liver substance. Most of the small intestine seemed distended, the proximal portion being soft

but the distal, rather firm. The duodenal junction and appendix were found in the left lower portion of the mass of herniated organs. At two different locations in the colon there was narrowing of the lumen but obstruction was not complete. The superior mesenteric artery had no direct relation to the duodenum. Rotation was apparently normal up to the point of withdrawal from the cord.

Other anomalies encountered were cranium bifidum, congenital asperitation of the fingers of the left hand, webbing between the 3d and 4th toes of the left foot, and right clubbed foot.

#### EVALUATION

The present series of cases illustrates the possible variation in the severity of omphalocele ranging as it does from that in Case 1 which presented relatively simple herniation of a portion of the intestine to that in Case 5 in which the major abdominal viscera were outside the peritoneal cavity and were not even covered by a membranous sac. Fortunately the commonest cases are the least severe. They consist typically of transparent or translucent sac in which is found a loop of the intestine. Rarely are other organs present without the intestine. As pointed

the liver with the sac attached and close the abdomen as usual. Placing a superficial structure inside the abdomen may sound unconventional but such cases, without resulting peritonitis, have been reported by Stanton and by Searle and Ingmire.

Closure of the abdominal wall should be attempted at all odds. Successful repairs have been accomplished even in those cases in which the sac of the omphalocele had been torn. The authors find no case reported, however, in which there has been an attempt to close the abdomen when the sac of the omphalocele was entirely absent.

Dott, in his report of 2 cases, emphasized the necessity of replacing the viscera, particularly the bowel, in as normal an anatomical position as possible. Since the gut is usually very poorly fixed in cases of omphalocele, volvulus may occur subsequently when proper fixation is not provided at surgery.

It is pointed out by Ladd and Gross that although newborn infants usually tolerate the shock of anesthesia and surgery, there are 3 complications that may arise: first, respiratory embarrassment and cyanosis may result from the upward pressure of the diaphragm, second, abdominal pressure against the inferior vena cava may produce circulatory collapse, and, third, excessive pressure against the intestine may cause temporary or partial obstruction. If the infant survives the 48 hours following operation, the chances for recovery are excellent.

According to O'Leary and Clymes the prognosis in omphalocele depends upon the diameter of the abdominal defect, the size of the hernial mass, and the time elapsing before intervention. To this list should be added the particular viscera that happen to be contained within the sac.

Of 20 cases reported by Gross and Blodgett, 10 survived. Most of those lost were in the early part of the series when an attempt was always made to close the fascia. O'Leary and Clymes, in their review of 91 cases, give a mortality rate of only 21.4 per cent for cases operated upon within the first 12 hours. In those who had surgery after 24 hours, the mortality rate was 61.6 per cent. This re-emphasizes the necessity for immediate surgery.

## SUMMARY

Five cases of omphalocele are reported. Of the 5, 1 was born dead, another lived but a few minutes, and the remaining 3 were treated surgically. Of these 3, 1 died 10 hours following surgery and 2 survived. One of these is known to be in good health at the age of 2½ years.

The embryology of omphalocele is discussed.

Associated anomalies are commonly found.

Surgical treatment within 6 hours of birth is advisable and offers, with occasional exceptions, the only chance of survival. The prognosis depends upon the time elapsing before surgery, the diameter of the defect in the abdominal wall, the size of the hernia, and the nature of the contents of the sac. Newborn infants tolerate anesthesia and heavy surgery surprisingly well.

## REFERENCES

- 1 ARTHUR, I. B. *Developmental Anatomy*. Philadelphia and London: W. B. Saunders, 1940.
- 2 BARDEFEN, C. R. *Am J Anat*, 1914, 16: 427.
- 3 BUBIS, J. L. *West J Surg*, 1942, 50: 165.
- 4 CLAGETT, O. T., and DIXON, C. F. *Proc Mayo Clin*, 1940, 15: 433.
- 5 DOTT, N. M. *Brit J Surg*, 1923, 11: 251.
- 6 GLASS, O. *Am J Obst*, 1935, 20: 748.
- 7 GROSS, R. E., and BLODGETT, J. B. *Surg Gyn Obst*, 1940, 71: 520.
- 8 HAYES, C. E., and McILROY, P. T. *Am J Surg*, 1933, 21: 297.
- 9 JARCHO, J. *Surg Gyn Obst*, 1937, 65: 593.
- 10 KLOPP, J. J. *Ann Surg*, 1921, 73: 642.
- 11 KRUMH, J. J. *Am J Obst*, 1931, 22: 442.
- 12 LADD, W. I., and GROSS, R. E. *Abdominal Surgery of Infancy and Childhood*. Philadelphia and London: W. B. Saunders, 1941.
- 13 MALL, J. P. Cited by Lewis, F. T. *Keibel and Mall's Manual of Human Embryology*. Philadelphia and London: J. B. Lippincott, 1912.
- 14 MILCH, H. *Am J Dis Child*, 1931, 42: 608.
- 15 NIEBUHR, W. A., DRESCH, C. A., and LOGAN, F. W. *J Am M Ass*, 1934, 103: 16.
- 16 O'LEARY, C. M., and CLAMBER, C. E. *Am J Surg*, 1941, 52: 38.
- 17 SEARLE, G. J., JR., and INGMIRE, J. *Ohio M J*, 1941, 37: 551.
- 18 STANTON, N. B. *Am J Surg*, 1939, 44: 646.
- 19 STRIN, J. I., and GRIFFIN, A. *J Pediat*, S. Louis, 1939, 14: 89.
- 20 THUNIG, I. A. *Arch Surg*, 1936, 33: 1021.
- 21 TRULSDALF, P. I. *J Am M Ass*, 1935, 104: 1697.
- 22 WILLIAMS, C. *Surg Clin N America*, 1930, 10: 805.



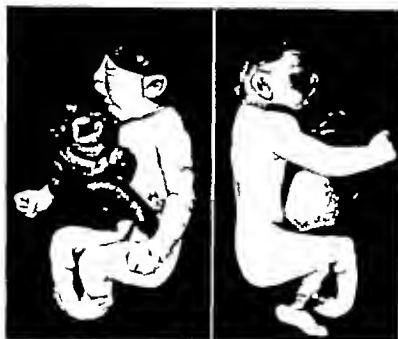


Fig. 4. Photograph of infant in Case 3, showing ectopic testis, cranial bifidum, amputation of fingers of the left hand and clubbed foot.

conservative treatment is justified only when surgical facilities are not available. Although a few cases have survived such conservative treatment as adhesive plaster or alcohol compresses, in the average case, surgery provides the only rational method of treatment. It is advisable to operate within 6 hours of birth for the reason that at this time the intestinal contents are as yet, sterile and negligible in quantity. No feeding should be permitted prior to surgery.

The precise technique of operation will vary with the findings in each case; no fast rules can be laid down. Ladd and Gross state that replacement of the viscera, excision of the sac, and closure of the abdominal wall are the essential features. It is admitted that replacement may be difficult in a poorly developed abdomen.

At operation, each umbilical vessel must be carefully ligated as it is encountered. Healing is more prompt and the scar stronger if the edges of the sac are freshened before closure. Precaution must be taken, however, lest so much skin be cut away that there is insufficient to cover the wound. A safe procedure is to leave the trimming of the skin until the excess can be determined at closure. After the layers of muscle and fascia are freed as much as possible, the peritoneum and posterior

rectus sheath should be closed by continuous suture. The recti can then be sutured together in the midline, the anterior rectus sheath approximated, and the skin closed.

In many cases (as in Cases 2 and 3 of the present series) the closing of the abdomen is the most difficult part of the surgical procedure. In some cases the wound can be closed by layers while in others this is impossible and it becomes necessary to use heavy interrupted, through-and-through silk sutures. In still other cases only the skin can be approximated. Secondary repair of the wall after it has stretched may be necessary when the wound cannot be closed by layers. O'Leary and Clymer mention that the extraperitoneal method of closure is preferable but admit that it is often impractical.

Something should be said of the method of handling the adhesions which are commonly found between the sac and its contents. Adhesions between the intestine and the sac can usually be readily separated. This is not true, however, of adhesions between the liver and the sac. Regardless of the care taken, troublesome bleeding may result after adhesions are stripped from the liver. If the liver is so adherent that hemorrhage seems inevitable, the procedure of choice is to replace

the liver with the sac attached and close the abdomen as usual. Placing a superficial structure inside the abdomen may sound unconventional but such cases, without resulting peritonitis, have been reported by Stanton and by Searle and Ingmire.

Closure of the abdominal wall should be attempted at all odds. Successful repairs have been accomplished even in those cases in which the sac of the omphalocele had been torn. The authors find no case reported, however, in which there has been an attempt to close the abdomen when the sac of the omphalocele was entirely absent.

Dott, in his report of 2 cases, emphasized the necessity of replacing the viscera, particularly the bowel, in as normal an anatomical position as possible. Since the gut is usually very poorly fixed in cases of omphalocele, volvulus may occur subsequently when proper fixation is not provided at surgery.

It is pointed out by Ladd and Gross that although newborn infants usually tolerate the shock of anesthesia and surgery, there are 3 complications that may arise: first, respiratory embarrassment and cyanosis may result from the upward pressure of the diaphragm, second, abdominal pressure against the inferior vena cava may produce circulatory collapse, and, third, excessive pressure against the intestine may cause temporary or partial obstruction. If the infant survives the 48 hours following operation, the chances for recovery are excellent.

According to O'Leary and Clymes the prognosis in omphalocele depends upon the diameter of the abdominal defect, the size of the hernial mass, and the time elapsing before intervention. To this list should be added the particular viscera that happen to be contained within the sac.

Of 20 cases reported by Gross and Blodgett, 10 survived. Most of those lost were in the early part of the series when an attempt was always made to close the fascia. O'Leary and Clymes, in their review of 91 cases, give a mortality rate of only 21.4 per cent for cases operated upon within the first 12 hours. In those who had surgery after 24 hours, the mortality rate was 61.6 per cent. This re-emphasizes the necessity for immediate surgery.

#### SUMMARY

Five cases of omphalocele are reported. Of the 5, 1 was born dead, another lived but a few minutes, and the remaining 3 were treated surgically. Of these 3, 1 died 10 hours following surgery and 2 survived. One of these is known to be in good health at the age of 2½ years.

The embryology of omphalocele is discussed.

Associated anomalies are commonly found.

Surgical treatment within 6 hours of birth is advisable and offers, with occasional exceptions, the only chance of survival. The prognosis depends upon the time elapsing before surgery, the diameter of the defect in the abdominal wall, the size of the hernia, and the nature of the contents of the sac. Newborn infants tolerate anesthesia and heavy surgery surprisingly well.

#### REFERENCES

- 1 AREY, L. B. *Developmental Anatomy*. Philadelphia and London: W. B. Saunders, 1940.
- 2 BARDEEN, C. R. *Am J Anat.*, 1914, 16: 427.
- 3 BUBIS, J. L. *West J Surg.*, 1942, 50: 165.
- 4 CLAGETT, O. T., and DIXON, C. F. *Proc Mayo Clin.*, 1940, 15: 433.
- 5 DOTT, N. M. *Brit. J Surg.*, 1923, 11: 251.
- 6 GLASS, O. *Am J Obst.*, 1935, 29: 748.
- 7 GROSS, R. E., and BLODGETT, J. B. *Surg Gyn Obst.*, 1940, 71: 520.
- 8 HAINES, C. E., and McILROY, P. T. *Am J Surg.*, 1933, 21: 297.
- 9 JARCHO, J. *Surg Gyn Obst.*, 1937, 65: 593.
- 10 KLOPP, E. J. *Ann Surg.*, 1921, 73: 642.
- 11 KRUMH, J. F. *Am J Obst.*, 1931, 22: 442.
- 12 LADD, W. E., and GROSS, R. E. *Abdominal Surgery of Infancy and Childhood*. Philadelphia and London: W. B. Saunders, 1941.
- 13 MALL, F. P. Cited by Lewis, F. T. *Keibel and Mall's Manual of Human Embryology*. Philadelphia and London: J. B. Lippincott, 1912.
- 14 MILCH, H. *Am J Dis Child.*, 1931, 42: 608.
- 15 NIEBUHR, W. A., DRESCH, C. A., and LOGAN, F. W. *J Am M Ass.*, 1934, 103: 16.
- 16 O'LEARY, C. M., and CLYMER, C. E. *Am J Surg.*, 1941, 52: 38.
- 17 SEARLE, G. J., JR., and INGMIRE, J. *Ohio M J.*, 1941, 37: 551.
- 18 STANTON, N. B. *Am J Surg.*, 1939, 44: 646.
- 19 STEIN, J. L., and GERBER, A. *J Pediat.*, S. Louis, 1939, 14: 89.
- 20 THUNIG, L. A. *Arch Surg.*, 1936, 33: 1021.
- 21 TRUESDALE, P. E. *J Am M Ass.*, 1935, 104: 1697.
- 22 WILLIAMS, C. *Surg Clin N America*, 1930, 10: 805.

# AVULSION OF SCROTUM AND SKIN OF PENIS

## Technique of Delayed and Immediate Repair

LOUIS T BYARS MD F.A.C.S. St. Louis, Missouri

**A**VULSION of penile and scrotal tissue has occurred in 3 cases. In each instance it was the result of loose clothing being caught in rapidly moving machinery. In the first case (Fig. 1) a hanging overall strap became engaged in a tractor belt, thus pulling the man into the machinery, stripping his overalls from him, and catching the loose skin of the scrotum and penis in the twisting overalls. The second case was the result of a power-driven drill-bit catching the overalls and twisting them and the skin of the genitalia. In the third and most recent case the workman was astraddle power-driven shaft, from which was projecting a set-screw. The rotary motion of the shaft engaged the overalls, which in turn caught the penile and scrotal tissues (Fig. 2). In 2 of these cases, the scrotum, a portion of the pubic skin, and most of the penile skin was avulsed. In one of these, one testicle was torn away. In the third, approximately two-thirds of the scrotum was taken along with the penile skin.

Such defects of the genitalia are rather rare. Brown (2) has reported 2 cases with loss of the skin of the shaft of the penis following circumcision, the third, the result of granuloma inguinale, and a fourth the result of a gunshot wound. Owens has reviewed the literature and reported repair in 3 cases. It is obvious that this type of deformity can present an acute problem to the patient aside from the functional aspect. It may also present a difficult problem of repair to the doctor.

**Selection of tissue for repair.** Pedicle scrotal flaps supply the most desirable tissue for covering penile defects because of the elasticity of the transplanted skin (1). This is especially true when there has been damage to the cavernosum with deep scarring and contraction. In many of these cases scrotal tissue is not available since it also has been lost. Even under ideal circumstances, the scrotal tissue may be inadequate in amount for complete coverage of the penis. A third point to be considered is that a wound of the penis which has contracted may undergo further contraction during the period of attachment of the penis to the scrotal flap.

Pedicle flaps from other portions of the body are too thick and lack the desired elasticity.

**Free skin grafts.** Thick, split skin grafts seem to answer most nearly the needs in the average case. If possible, it is sometimes desirable to use a combination of scrotal flap and free skin graft, especially to prevent possible scar constriction about the base of the penis. The difficulty of take in this area makes the free full thickness graft less desirable. The dead stages of the free skin graft are that the skin is not as expandable as is normal penile skin and that the grafts tend to contract for a period after their application. Both of these difficulties may largely be overcome by the transplantation of an adequate amount of skin. This is done by making the wound the maximum size at the time of application and by supplementing the graft if necessary at a second operation.

**Preoperative preparation of the ulcerated wound.** This is the same as that which has previously been described for ulcerations of other types (3, 4). All surrounding hair should be kept short, the area should be frequently cleansed by the use of soap and water, sulfanilamide or sulfathiazole powder should be dusted on the surfaces one or more times daily. The patient sits in a saline bath for several hours daily if possible. After debridement, sterile fine mesh gauze is applied to the wound, and over this is applied firm, bulky normal saline dressing held in place with a suspensory or athletic supporter. This dressing is changed frequently. When the granulations have become compact and uniformly red, and there is a minimum of discharge on the dressings, and the appearance of the wound has ceased to improve it is ready for grafting.

**Operative technique.** Granulation tissue is trimmed away with sharp knife carefully dissecting away the deeper scar until the penis is completely elongated and freed from the contraction which has resulted from partial healing. All bleeding points are carefully ligated with finest available silk. If there is loss of the normal skin left on the penis, either about its base or the glans, this skin is retracted. A collar of skin about the base of the penis can be sutured back as a roll at its junction with the abdominal wall. A collar of skin about

From the Department of Surgery, Washington University School of Medicine.



Fig 1 a, left, Granulating wound and absence of scrotum as result of avulsion of these tissues. Both testicles were transplanted into the inguinal canals by the surgeon giving them emergency treatment. There is considerable shortening of the penis. b, Result 3 months after split skin grafting. There is still some shortening of the penis. The graft is becoming soft and flexible. A second operation was done subsequent to this, a circular incision being made about the base of the penis, the penis being elongated by dissection of scar, and a second graft being applied to this area. Photograph subsequent to second operation was not obtained but patient had functional result.

its attachment to the glans can be drawn toward the tip of the penis in a similar manner. This makes available a larger wound for grafting and consequently aids in getting the desired excess of skin on the wound. If a perineal or scrotal ulceration is present, it is similarly prepared by excision of granulations and underlying scar.

A split thickness skin graft, approximately two thirds the thickness of the skin, is taken, if possible, getting one piece large enough to cover the entire wound. A catheter is inserted into the bladder, and the penis is held completely extended. The graft is draped over the wound, and sutured accurately to the wound borders, proximally and distally, with interrupted sutures. Where the borders of the graft meet, they are sutured together with a running silk suture, slightly overlapping the graft borders to insure complete coverage of the defect. The graft is applied under normal skin tension. The interrupted sutures at the proximal and distal borders of the graft are left long. Quilting stitches may be applied, longitudinally, up and down the graft, but these must not go in a circular manner about the penis, for fear of a tourniquet effect if erection occurs (Fig 3a). If the graft extends down in the perineum or on to the scrotum, it is sutured here with long interrupted silk sutures. The graft is dressed by dusting it with sulfanilamide powder

and then covering it with fine-mesh gauze impregnated with some bland ointment. A large bulk of cotton machinist's waste is built up around the defect. This is held in place by tying the interrupted sutures at the proximal junction of the graft and skin to those at the distal junction over the pad of waste. The sutures on the lateral borders of the perineal defect are tied together over the pad of machinist's waste (Fig 3b). This fixation of the dressing with sutures preserves the elongated position of the penis, and serves as a splint to the wound. It keeps the tension on the applied graft uniform. Over this dressing is applied a very bulky mass of gauze and the entire dressing is firmly bandaged in place around the upper thighs and abdomen.

*Postoperative care.* The first wound dressing is done on the 4th or 5th postoperative day. At this time most of the sutures are removed, the graft is cleaned gently with boric solution and is powdered with sulfanilamide powder. A dressing as nearly like the original as possible is reapplied. After the 7th or 8th postoperative day, the catheter is removed, and a similar but less bulky dressing is applied, and held in place with an athletic supporter. Split thickness grafts undergo a period of contraction during the first 2 months. Following this, they begin to soften and relax. In 1 of the 3 cases described, a second operation was



Fig. 2. a, Photograph of wound taken at time of operation, 8 hours after accident. There has been an avulsion of the right testicle, all of the scrotum, most of the penile skin, and a portion of the skin of the pubic region. b, Photograph taken 3 days later, at time of first dressing of the

graft. The graft-covered testicle is shown just outside the urethral ring. There was almost complete loss of the graft. c, Result 7 weeks after operation. Grafted skin is becoming soft and pliable and seems adequate in amount. Patient did not desire transplantation of testicle into inguinal canal.

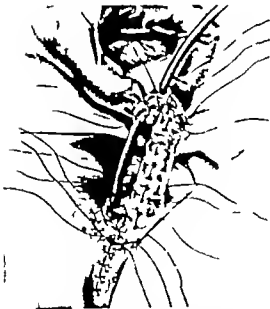


Fig. 3. a, left, Diagrammatic presentation of method of applying split-thickness skin graft as it was done in case illustrated in Figure 2. The testicle is omitted from the drawing for simplification. b, Illustrating fixation of dressing. Adjacent to the graft has been applied a layer of fine mesh vaseline gauze. On top of this is built up a mass of macchiavello's waste, and the sutures at the proximal junction



of the penis and skin graft have been tied to those at the distal junction over the testis in such a manner as to maintain elongation of the penis and give the maximum length of wound to repair the skin graft. Over this will be applied very heavy and bulky dressing which firmly bandaged in place about the abdomen and thighs.

## BYARS AVULSION OF SCROTUM AND SKIN OF PENIS

done, supplementing the original graft to give additional length to the penis (Fig 1) In all cases, the skin has eventually become soft, reasonably loose, and of a normal sensation

*Repair of defect immediately after injury* In 1 case, the patient was received 18 hours after the accident (Fig 2)

His attending physician had first seen the man a few moments after the injury Bleeding was slight He had shaved the surrounding area, removed gross contamination, freely covered the wound with sulfanilamide powder, and as quickly as possible transported him to Barnes Hospital This 53 year old man was suffering little pain, and stated that the pain had never been severe He was having no difficulty voiding At examination it was found that a small collar of skin remained about the glans All other penile skin, including a portion of pubic skin, and the entire scrotum were missing The right testicle and cord were absent The left testicle was present, completely exposed It was somewhat edematous and swollen Much hair was imbedded in the wound There was no cellulitis The area was gently washed with sterile soap and gauze The wound was irrigated copiously with large amounts of saline, and all foreign material was picked out of the wound Following this, the perineal wound was sutured in the midline, as far as it could be closed without tension The testicle was sutured in the external inguinal ring with interrupted sutures, much after the fashion of a cork in a bottle Because of the duration of the wound and the contamination, it was not considered desirable to open up further tissue as would have been necessary to implant this testicle in the inguinal canal A large single split graft was then applied to the penis, the open portion of the perineal wound, and over the exposed part of the testicle This was dressed as previously described There was almost complete take of the graft The patient had very little pain or local difficulty at any time On the 12th postoperative day, patient had a pulmonary embolus from which he recovered A second such accident occurred on the 25th postoperative day These were presumably from the traumatized spermatic veins Never at any time did he have any infection about the wound At the time of the last observation, patient was completely healed and the graft was soft and flexible enough to permit normal function The skin graft covered testicle was in a position as shown in Figure 2c. It was proposed to transplant this higher in the inguinal canal to place it in a less exposed position, but the patient did not consider this necessary

### CONCLUSION

These cases are presented first with the idea of expressing the desirability of primary repair rather than subjecting the patient to the prolonged discomfort coincidental with secondary repair In

addition, it is felt that skin grafting of properly prepared open wounds resulting from avulsed tissue is practical and should be considered even though a number of hours have elapsed since the injury In a number of cases heretofore, we have made use of the principle of grafting a freshly created traumatic wound with the idea of getting quick healing This may be especially important on the eyelids However, this is our first case as old as 18 hours that has been so treated Emphasis should be placed on the proper cleansing of the wound, regard for not introducing further contamination (5), and the use of sulfanilamide crystals

In none of the 3 cases was restoration of the scrotum attempted It is obvious that under some circumstances such a reconstruction might be considered essential If this is contemplated, the testicles should be planted under the skin and subcutaneous tissue of the upper, inner thighs at the time of the initial repair After the defect of the penis has been adequately repaired and healed, each testicle and its cord would be dissected free from the thigh, carrying with it the overlying skin and fat The tissue from the right and left thighs would then be sutured together in the midline, the testicles with their overlying skin and fat being joined to make the two halves of the reconstructed scrotum This would occupy approximately the normal position and probably maintain nearly the optimum temperature of these organs This reconstructed scrotum would not be contractile The two donor sites on the inner surface of the thigh would be covered with split thickness skin grafts

### REFERENCES

- 1 BLAIR, VILRAY P, and BYARS, LOUIS T J Urol, 1938, 40 814-825
- 2 BROWN, JAMES BARRETT Surg Gyn Obst., 1937, 65 362-365
- 3 BROWN, JAMES BARRETT, BYARS, LOUIS T, and BLAIR, VILRAY P Surg Gyn Obst, 1936, 63 331-340
- 4 BROWN, JAMES BARRETT, BYARS, LOUIS T, and McDOWELL, FRANK Arch Surg, 1940, 40 1102-1111
- 5 KOCH, SUMNER L Surg Gyn Obst, 1943, 76 1-22, 189-196
- 6 OWENS, NEAL. Surgery, 1942, 12 88-95

# EDITORIALS

## SURGERY Gynecology and Obstetrics

FRANKLIN H. MARTIN  
Founder and Managing Editor  
905 935

---

LOYAL DAVIS, EDITOR

*Associate*

SUMNER L. KOCH      MICHAEL L. MASON

---

DO ALD C. BALFOUR, *Associate Editorial Staff*

---

SEPTEMBER, 1941

---

## INFECTIONS OF THE URINARY TRACT

WHEN one peruses the voluminous literature on infection of the urinary tract which has appeared in the past decade one is impressed first of all by the tremendous progress which has been made in the treatment of this disease. To begin with this advancement was largely stimulated by the work of Helmholtz and Clark on the bacteriological aspects of infections of the urinary tract. Their studies have contributed much to present day knowledge, but only too frequently are their methods thrown aside and treatment carried out empirically.

With the development of the numerous sulfonamide compounds and their known efficacy in combating infections of the urinary tract many physicians prescribe these drugs without a sufficient knowledge of the underlying bacteria in the given case without knowing the true pathological changes and without proper respect for the various toxic manifestations which may develop in any case.

Complete bacteriological studies are not necessary in each case by any means. The expense to the patient is not justifiable. However a simple gram-stain of the urinary sediment which is at the disposal of all surgeons will usually suffice and lead one to the proper management of the patient. Cultures are helpful but are not always necessary.

By the same token one cannot expect every patient with an infection of the urinary tract to submit to a complete urological investigation. Many such patients may be cured of their illness with chemotherapy as their difficulty is superficial. However if after one or two courses of medication the desired results are not obtained these patients are entitled to a detailed urological investigation. It is well known that the percentage of cures in cases of infection of the urinary tract falls sharply when one passes from the uncomplicated to the complicated infection. Stone tumor obstruction, or chronic inflammatory changes in the kidneys definitely decrease the value of chemotherapy and in many instances this is of no value until the coexisting or primary pathological lesion is removed.

When considering the drugs themselves, one should not lose sight of the value of mandelic acid. It should not be used in cases of impaired renal function as in such cases it is toxic to the kidney. Concerning the sulfonamide compounds there is a very definite need for continued and close observation while the patient is taking the drug. Many compounds have been used and rightfully so as some are more toxic in one case than in another some more efficacious in one case than in another.

If everything possible is to be secured from chemotherapy in infections of the urinary

tract, a close check on each individual patient must be kept. Doses should not be excessive. Helmholtz has repeatedly demonstrated experimentally that small concentrations of any of these drugs will sterilize the urine. This has been borne out clinically. Seldom if ever, will increased doses do more than will the usual small dose.

These remarks are a renewal of the plea for the proper management of urinary tract infections. There is no more grateful patient than one who suffers from vesical distress and is relieved of the irritating symptoms.

EDWARD N. COOL

## MODERN ANESTHESIOLOGY AND THE ANESTHETIST

THE development of modern anesthesiology and the training of anesthesiologists has always received my ardent support. It might be well to state, however, that any convictions I may have are the result of gratifying, convincing personal experiences and are not the result of an enthusiasm for a hobby or an interest in a personal program. The fact that many surgeons continue to be satisfied with nonmodern anesthesia and anesthesiologists, and the fact that these surgeons remain unaware of how much easier their work could be made to say nothing of the increased safety afforded their patients by more modern methods, prompt this statement.

Since the day when the Jahnke clinic was started the great opportunity to advance the standards of surgery by improving the methods of administering anesthetics and the training of anesthesiologists has been ever before me. The work of the anesthesiologist was formerly largely limited to the administration of ether, and anesthesiology was a neglected field. The expansion of surgical boundaries was thus limited by the use of a few anesthetic agents and

methods of administration by a few gentle natured, underpaid physicians.

Many anesthesiologists had gravitated into the field because it provided a refuge from competition in other fields of medical endeavor and a moderate but uncontested source of livelihood. This psychic haven of professional refuge was made still more attractive to these unaggressive personalities by the fact that the surgeon of that period usurped the complete responsibility for the type of anesthesia to be used, its depth and course, the patient's condition and any complications which the patient might suffer during or after the operation. Add to this the fact that the patient usually saw the anesthesiologist either briefly the night preceding the operation, or for the first time when anesthesia was about to be induced and almost never after operation and we are able to establish the base line from which has been evolved the present superstructure of the modern methods of administering anesthetics and of training anesthesiologists. Unfortunately, in many institutions anesthesiology is still at or near this base line level.

In order to emphasize the nature of modern anesthesiology as well as the accomplishments of a modern anesthesiologist, it might be well to mention the ideals to be attained in the training of an anesthesiologist.

He should have a fundamental knowledge of pharmacology and physiology, he should be able to induce expertly all types of anesthesia, he should, of course, be familiar with the newer agents and the methods of their administration, as, for instance, the induction of fractional (continuous) spinal anesthesia and anesthesia by means of the intravenous injection of the barbiturates. However, he should not neglect the older but still valuable agents and methods, it is still very important that the anesthesiologist be expert in inducing ether anesthesia and that he be able to recog-



nize in a given case the value as well as the limitations of the use of nitrous oxide gas anesthesia particularly with reference to the immediate and remote effects of anoxia. He should be able and be permitted to exercise judgment in the selection of the anesthetic agent and method be considers best adapted to the patient and the proposed operation.

He should be able to administer cyclopropane but he should also be cognizant of the possible dangers associated with the use of this agent in certain types of patients particularly with reference to the possibility of producing cardiac irregularity and even ventricular fibrillation in the presence of a damaged myocardium. He should be familiar with and constantly aware of the explosion hazard and should fully recognize that this hazard is not limited to ethylene and cyclopropane but is also present when nitrous oxide oxygen and ether or oxygen and ether combination are used. He should be aware not only of the various explosive anesthetic mixtures but should be acutely aware of the importance of the static spark as the causative agent in so many explosions. Furthermore he should be familiar with the recognized safety methods that have been developed as protection against explosion.

He should be familiar with the use of a direct laryngoscope either for the passing of an endotracheal catheter or the inspection of the larynx and vocal cords. In fact, no matter how much the trachea is deviated or narrowed he should be capable of introducing an endotracheal catheter either by the direct route or by one of the so called "blind" methods of intubation.

He should recognize the importance of keeping the tracheobronchial tree free of secretions and other fluid, and should be prepared and able to remove these secretions before operation during operation, and after operation

in other words he should be familiar with the technique of bronchoscopy and should be able to recognize when this procedure is indicated.

He should be capable of maintaining constant positive pressure anesthesia when indicated and of maintaining artificial respiration when for any reason such as an overdose of an anesthetic agent or the spinal anesthesia has inadvertently gone too high the patient is unable to maintain his own respiration.

His knowledge of spinal anesthesia should not be limited to the use of procaine crystals but he should be familiar with the various pontocaine and nupercaine techniques, as well as with fractional (continuous) spinal anesthesia. He should be capable of inducing all types of regional anesthesia as well as carrying out all the various nerve blocks for diagnostic and therapeutic purposes.

Gas therapy quite logically falls within the scope of anesthesiology. The well trained anesthetist should be capable of supervising all types of gas therapy particularly administration of 100 per cent oxygen and helium.

This editorial is based upon the teaching program employed in this clinic for the instruction of its fellows in anesthesiology. Similar instruction is also available in many other institutions. It can be said, therefore, that the refinements in producing anesthesia here mentioned are not merely ideals but actual accomplishments and that as such they are attracting extremely capable and enthusiastic young men to this field. The improvements in the practice of anesthesiology have opened up another relatively new field of medical endeavor which has not only widened the range of surgical undertakings but has also made surgical operations less of a physical and emotional ordeal for the patient and also for the surgeon. This statement is truly borne out by our experience. FRANK H. LUNNEY

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

THE authoritative monograph on the physiology of external pancreatic secretion and diseases of the pancreas, *Exocrine Function and Diseases of the Pancreas* by Henrik O. Lagerlöf, is a painstakingly accurate review of all prior work on the subject supplemented by extensive investigations by the author and his associates in Bergh's clinic in St. Erik's Hospital in Stockholm. It is translated into English by Helen D. Treg and contains a commendatory foreword by Dr. Joseph H. Pratt of Boston, a recognized authority on the subject.

The monograph is divided into five sections. The first concerns the physiology of pancreatic secretion exclusively. Complete reviews of all other work on the subject include the chief contributions of Claude Bernard, Paulin Boyer, and Stirling Hammarsten, Halblin, and Ivy. The author's experimental work with Agren and others is described in detail, including methods and results. By means of secretin, the secretion of pancreatic juice and analysis of its constituents, establishes normal human function as clearly as is possible at the present time. Lagerlöf's studies are unique in that his methods permit the collection of human pancreatic secretion uncontaminated by gastric juice or saliva and uninfluenced by passage of acid chyme into the duodenum. A double tube makes this possible, one aspirating pancreatic juice from the jejunum and the other simultaneously aspirating all gastric contents from the higher ileum. The English account of reports of these experiments and their correlation with other pertinent data makes this volume indispensable to all physiologists.

Of even greater value is the review of pancreatic diseases and their study by improved methods of pancreatic juice analysis. The last four sections of the monograph describe pancreatic diseases, their differential diagnosis, their study by means of the secretin test and enzyme analysis with illuminating case reports and appendices. The bibliography of 355 references to published data on the subjects of the monograph indicates the thoroughness of the author's coverage.

As expressed by Dr. Pratt in the foreword, "The work reported by Lagerlöf has lifted pancreatic analysis to the level gastric analysis has occupied for many years. Unquestionably this monograph is the most complete and authoritative review of pancreatic external secretion function and disease

in existence. It should be studied and its clinical methods employed by every gastroenterologist."

ARNOLD K. CORWIN

AN excellent monograph by Charles C. Higgins on the subject of urinary lithiasis has recently been published. In a brief but comprehensive manner the history, etiology, symptomatology, and treatment are concluded as to make interesting as well as instructive reading. The author has long been interested in the etiology of renal calculi and has previously made valuable contributions along this line. The one together with the more pertinent work of others have been completely but simply arranged so that the summary is clearly understandable.

Methods for the qualitative analysis of renal calculi are presented. The dietary methods for attempting the dissolution of renal calculi, as well as a preventive for recurrence after spontaneous passage or surgical removal are discussed in great detail. The author presents many carefully formulated diets to be advocated in these patients. All diets are based upon complete and satisfactory analyses of the chemical components of the calculi recovered or removed from each patient.

VINCENT J. O'CONNOR

THE small volume entitled *Burns, Shock, Wound Healing, and Vascular Injuries*, prepared under the auspices of the National Research Council is rich in authoritative and practical information. Its authors have done an outstanding piece of work for the medical officers in the armed services in making available to them in condensed and readable form up-to-date conceptions of burns, shock, and wound healing. Moreover, this book should be in the hands of every civilian physician who is concerned with these conditions.

The first section of the book deals with burns and was prepared by a committee headed by Roy D. McClure and including Conrad R. Lam, Henry N. Harlins, James Barrett Brown, and David P. Barr. The general treatment of the patient with a severe burn is dealt with in detail. The early local treatment of the burned area is thoughtfully considered, and a table is included giving the committee's choice of local treatment of the various burned regions of the body in accordance with the depth of the burn.

RENAL LITHIASIS. By Charles C. Higgins, M.D. Springfield, Ill.: Charles C. Thomas Co., 1931.

MILITARY SURGICAL MANUALS. VOLUME 8. BURNS, SHOCK, WOUND HEALING, AND VASCULAR INJURIES. Prepared under the auspices of the Committee on Surgery of the Division of Medical Sciences of the National Research Council. Philadelphia and London: W. B. Saunders Co., 1935.

PANCREATIC FUNCTION AND EXOCRINE DISORDERS. STUDIED BY MEANS OF SECRETIN. By Henrik O. Lagerlöf, M.D. Translated by Helen D. Treg, with a foreword by Joseph H. Pratt, M.D. New York: The Macmillan Co., 1937.

the care of the granulating surface, the early plastic treatment of burns, and skin grafting for contractures following burns. There is a short but valuable chapter on burns—chemical warfare.

The section on shock has been prepared by a committee led by Alfred Blalock, chairman, and including Philip Bard, Norman E. Freeman, Frank C. Mann, Henry K. U. Beecher, Paul D. Lamson, D. B. Phenister, and Max M. Strumia. This clear presentation may be found a satisfactory definition of shock and a consideration of the criteria pathology and factors in the production of shock, and the prevention and treatment of shock, including an entire chapter devoted to fluid replacement therapy.

The section dealing with wound healing has been prepared by Allen O. Whipple and is a classic description of the subject. The section on vascular injuries has been prepared by a committee headed by John Homans and including Arthur W. Allen, Daniel C. Elkins, Gena de T. Kats and Walter G. Maddock. This very valuable section discusses the treatment of hemorrhage and the injuries to large arteries in general. The injuries of arteries in special locations are taken up individually. Diseases of the arteries and of the veins are succinctly presented. This section is beautifully illustrated by means of excellent line drawings.

This volume is a clearcut, brief summation by outstanding men of the really important knowledge of the various subjects. It can be recommended most highly.

FREDERICK CHRISTOPHER.

THE eighth edition and the new text of *Diseases of the Nose, Throat and Ear* by William and Howard Ballenger will creditably live up to the high standard set for it by the previous editions which have all been foremost in this field.

The book has been revised and practically rewritten many things which have become obsolete have been eliminated and an abundance of new material has been added along with numerous illustrations in black and white and in color.

Dr. Brian T. King and Dr. J. D. Kelly have contributed a description of their surgical procedures for the relief of bilateral paralysis of the recurrent laryngeal nerves, and Dr. Alfred Lewy also has written an excellent chapter on physiology, functional tests, and inflammatory diseases of the larynx. A chapter on paralysis and neurosis of the larynx has been very well done by Dr. John J. Ballenger. Dr. Chevalier L. Jackson has revised the chapter on direct laryngoscopy, bronchoscopy, esophagoscopy and gastroscopy. The technique of each procedure is carefully described and illustrated with instructive pictures. The diagnosis, pathology and treatment are discussed in each condition.

The chapter on gastroscopy gives a good description of the Schindler flexible gastroscope and its advantages in examining the interior of the stomach.

The Lempert fenestration operation for relief of deafness due to otosclerosis is fully described and with many illustrations showing the various steps of this procedure. Also the endaural mastoidectomy for the relief of chronic suppurative otitis media is described.

This book is written in an easy to read style and covers in a comprehensive way the entire field of otolaryngology thus making it a most valuable text for the specialist and the general practitioner and the student.

LEON F. McNEAVE.

THE second volume by Doctor Troetsch relating his experiences in war surgery has been published. His first volume was printed in California during the recent Spanish war. This second volume is a detailed description of the "five point program" necessary in the treatment of wounds and fractures. The material was developed from his work at Spaulding and recently at the Wriggfield-Morris Orthopaedic Hospital. The book contains 400 pages.

With 144 illustrations and is divided into two parts. Part I depicts the pre-Listerian and post-Listerian history of surgery and indicates that the greatest progress in general surgery has been developed during wars. It reads the gain of Joseph Lister's contribution was not help but he warned of the analogy between phenol and the sulfonamides, for with the development of the aseptic technique the progress of surgery was hindered for a considerable time. Many surgeons came to think that the actual operative procedure was of minor significance and that success depended entirely upon the use of carbolic acid. The author completes Part I with a detailed but easily read report on the treatment of wounds, shock, gas bacillus infections, and tetanus as related to war surgery. Part II is the meat of his thoughts in regard to the biological treatment of wounds in five point program.

Prompt surgical treatment, with 6 hours. Cleaning of the wound with soap. "I am personally so convinced of its value that I could be willing to use almost any variety of soap in preference to the best chemical antiseptic yet known."

3. Excision of the wound. (It is well to discard the word débridement which means incision.) It requires considerable experience to learn the technique of proper and adequate excision which is probably the most important part of the five point program.

4. Provision for drainage. "The provision of adequate drainage not only for the tissues fluids that must be evacuated but also for the extravasated blood which fills every small corner of the wound demands special technique. The absorbent capacity of gauze, however high, is not unlimited, and consequently after a while it will be unable to absorb any further discharge. If the discharge is not

OF THE PRINCIPLES OF PRACTICE OF WAR SURGERY WITH REFERENCE TO THE ESSENTIAL METHODS OF TREATMENT OF WOUNDS AND INJURIES. BY J. TROETSCH, M.D., with collaboration by GLEN M. JOHNSON, M.D., and LEON F. McNEAVE. The C. C. Mosby Co. 1941.

to be retained in the wound, the gauze must be supplemented by some other substance still more absorbent than itself. Here the plaster cast provides one of its many advantages, for good plaster of Paris is very absorbent. It is important that the plaster should be applied in direct contact with the gauze, and its quality must be good, some brands on the market have little or no absorbent capacity. In treating compound fractures by the methods I describe, a nonhydrated plaster of Paris of the type called 'alabaster' should be used, for this when set is highly absorbent."

5 Immobilization in a plaster of Paris cast. The author writes in detail of the application of the plaster cast giving the advantages and disadvantages of both the plaster bandage and pattern technique. He describes the treatment for all types of fractures.

He writes of his success with the Corachán technique of skin grafting, articular wounds, amputations, and burns.

This book is a comprehensive, well written, easily read review of the work of many surgeons and put into a well organized workable plan by the author. It is not all new material for, as Dr. Wangenstein who wrote the introduction points out, Frederic S. Dennis, a New York surgeon in 1884, reported 244 compound fractures treated with soap and water, excision, and plaster cast. Those of us in America who adhere to the teachings of Kanavel and Koch will read this book without too much adverse criticism.

A senior medical student, interne, general surgeon, orthopedic surgeon and especially any doctor entering the armed service of his country would be greatly benefited by reading this book.

JOHN M. HOWELL.

THE outstanding feature of the remarkable little book *Essentials of Proctology*<sup>1</sup> by Harry E. Bacon is its vast content of accurate and pertinent information, beginning actually on the inner side of the front cover with a useful index of symptoms and signs. The author is thoroughly versed in the literature of his field and keeps well abreast of what his confreres in proctology are doing. These facts coupled with the author's extensive teaching and clinical experience render him well qualified for the task of authorship on proctological subjects.

The volume offers excellent illustrations, done by a well recognized medical artist, and presents several

<sup>1</sup>ESSENTIALS OF PROCTOLOGY. By Harry E. Bacon, B.S. M.D., F.A.C.S. F.A.P.S. With an introduction by Curtice Rosser, B.A. M.D., F.A.C.S. F.A.P.S. Philadelphia: London, Montreal: J. B. Lippincott Co. 1943.

differential diagnostic tables which should appeal to student and to practitioner alike.

Although the author mentions the etiological factor of cryptitis in anorectal inflammatory disease he omits any discussion of the rôle of anal glands, anal ducts and lymphatics in the pathogenesis of the common anorectal infections. This factor of "anal infection," brought forth by Herrmann some 60 years ago is again receiving recognition.

Bacon describes anorectal abscesses in one chapter and anorectal fistulas in another. The reviewer subscribes to Baile's belief that abscess and fistula merit consideration in one and the same chapter, thus stressing, from the teaching standpoint, the fact that an anal abscess is merely a step in the pathogenesis of an anal fistula. An additional objection is raised to the use of the adjective "incomplete" pertaining to fistula. If a fistula (so called) is incomplete it is not a fistula, it is a sinus!

The author's presentation of venereal lymphogranuloma is indeed excellent, portraying in brief the results of the extensive study he has made of this entity. However, the author refers to a "difference in male and female lymph drainage" as responsible for different clinical manifestations in the two sexes. Actually the arrangement of the lymphatics is the same in homologous structures in the male and female. The difference in clinical manifestations of venereal lymphogranuloma in the two sexes lies in the different sites of the primary lesion, i.e. external genitalia in the male usually, and in internal genitalia in the female (posterior vaginal wall, and/or cervix).

In his discussion of pilonidal cysts the author omits mention, under treatment, of the method of exteriorization (described by Baile). This procedure has proved of great value in military surgery—current reports of the success of primary closure notwithstanding.

The reviewer regrets the lack of illustration of, and the lack of detail regarding the surgical management of anomalous anorectal conditions. When the practitioner does have need for such information he needs it quickly. Few surgeons can boast of an extensive experience in this problem.

Especially for the benefit of the student it would have been well to mention the use of soap and water in the preoperative preparation of the skin. The value of this procedure has been clearly set forth by Koch and his associates.

This timely volume is indeed an invaluable contribution to proctological literature.

J. PEERMAN NESSELROD

## CORRESPONDENCE

### CHEMICAL CONSIDERATIONS GOVERNING THE LOCAL CHEMOTHERAPY OF WOUND INFECTIONS

IT has been called to our attention that in the article entitled "Chemical Considerations Governing the Local Chemotherapy of Wound Infections," by the late Frank C. Schmeffler, in the July 1915 issue an error has been made in the use of the term "hydrogen ion concentration" and the symbol pH. The first paragraph on page 7 should read:

*Application of these findings to the local therapy of wounds and burns.* A has been shown, infected wounds are acid. Sulfonamides in general are much

less active under acidic conditions and between pH 5 and 6 even the more active compounds, sulfathiazole and sulfadiazine, exhibit only a fraction of their maximum activity. The activity of sulfonamides can be increased by raising the pH which increases their dissociation and apparently also increases the effectiveness of the molecular form. While the more active compounds sulfathiazole and sulfadiazine, are largely dissociated at pH 7, the activity of sulfanilamide can be raised to that of sulfathiazole and sulfadiazine by raising the pH from slightly above the neutral point up to pH 9. Due to the much greater solubility of sulfanilamide, a local hemotherapeutic effect might be had at pH 9 that could exceed that of sulfathiazole and sulfadiazine.

The Editors.

## BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections may be made for review in the interests of our readers and in space permits.

A HANDBOOK OF MEDICAL LIBRARY PRACTICE INCLUDING ANNOTATED BIBLIOGRAPHICAL GUIDES TO THE LITERATURE AND HISTORY OF THE MEDICAL AND ALLIED SCIENCES. Based on Preliminary Manuscript by M. Irene Jones. Compiled by Committee of the Medical Library Association. Edited by Janet Doe. Chicago: American Library Association, 1943.

PAIN MECHANISMS, A PSYCHOLOGICAL INTERPRETATION OF CALORIC AND ITS RELATIONSHIP TO THE LIVER. By Lieut. Commander M. C. U. S. N. R. New York: The Macmillan Co., 1943.

DIAGNOSIS OF UTERINE CANCER BY THE VAGINAL SPECULUM. By George W. Papadimitriou, M.D. Ph.D. and Herbert F. Treat, M.D. New York: The Commonwealth Fund, 1943.

PICTORIAL HANDBOOK OF FRACTURE TREATMENT. By Edward L. Compere, M.D., F.A.C.S. and Sam W. Banks, M.D. Chicago: The Year Book Publishers, Inc., 1943.

HUMAN GASTRIC FUNCTION, A EXPERIMENTAL STUDY OF MAN AND HIS STOMACH. By Stewart Wolf, M.D. Captain, M.C. A. U. S. and Harold G. Wolf, M.D. With foreword by Walter B. Cannon, M.D. London, New York, and Toronto: Oxford University Press, 1943.

MANUAL OF FRACTURES, THE TREAT BY EXTERNAL SKELETAL FIXATION. By C. M. Starr, M.D. F.A.C.S., Captain, Medical Corps, United States Navy, and Frank P. Kress, J. M.D. F.A.C.S., Lieutenant Commander, Medical Corps, United States Navy. Philadelphia and London: W. B. Saunders Co., 1943.

REMARKABLE TION OF THE WAR INJURED. A SYMPOSIUM. Edited by William Brown Doherty, M.D. and Dagobert D. Reiser, Ph.D. New York: Philosophical Library, 1943.

MEDICAL MALPRACTICE. By Louis J. Raper, M.D. LL.B. St. Louis: The C. V. Mosby Co., 1943.

HISTORY OF SURGERY. By Richard A. Leonardo, M.D. Ch. M. F.I.C.S. New York: Froben Press, 1943.

PETER'S SURGICAL FLUOROSCOPY: A MANUAL OF SURGICAL FLUOROSCOPY, MINOR SURGERY AND OTHER METHODS. EDITED BY THE WORK OF SURGICAL FLUOROSCOPY. HENRI SCHWARTZ, AND PRACTITIONERS. Edited by Hans-Rüdiger Bailey, F.R.C.S. (Eng.) 5th ed. Baltimore: The Williams & Wilkins Co., 1943.

SURGICAL CASES. ALL VOLUMES OF PETER'S SURGICAL FLUOROSCOPY. By R. W. Bailey, F.R.C.S. Major R.A.M.C. Baltimore: The Williams & Wilkins Co., 1943.

ANNUAL REPORT OF THE REPORTS OF THE COUNCIL OF PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION FOR 1943 WITH THE COMMENTS BY THE ASSOCIATION. CHICAGO: AMERICAN MEDICAL ASSOCIATION, 1943.

NEW AND NONOFFICIAL REMEDIES, 1943. ON THE DESCRIPTIONS OF THE ARTICLES WHICH HAVE BEEN ACCEPTED BY THE COUNCIL OF PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION ON JANUARY 1, 1943, UNDER THE DIRECTION AND SUPERVISION OF THE COUNCIL ON PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION. CHICAGO: AMERICAN MEDICAL ASSOCIATION, 1943.

ROENTGENOGRAPHIC TECHNIQUE. A MANUAL FOR PHYSICIAN, STUDENTS AND TECHNICIANS. By Dariusz W. Ruzhanski, A.M. M.D. F.A.C.R. 3rd ed. Philadelphia: Lea & Febiger, 1943.

THE GYNECOLOGY OF GYNAECOLOGY: HISTORY OF THE DEVELOPMENT OF GYNECOLOGY THROUGHOUT THE AGES, 3000 B.C. 3000 A.D. By James A. RICE, A.B. M.D. Philadelphia: The H. K. Lewis Co., 1943.

MANAGEMENT OF THE COLORECTAL CANCER. THE MANAGEMENT OF THE COLORECTAL CANCER. By Members of the Staff, Philadelphia, London, and Montreal: J. B. Lippincott Co., 1943.

A TREATISE ON ANATOMY. I. T. VOLKMER. By J. C. Bailett, M.C. M.B. Ch.B. F.R.C.S. (Edn.) Vol. UPPER LIMB, ARM, SHOULDER, PELVIS, AND LOWER LIMB. Baltimore: The Williams & Wilkins Co., 1943.

THEORY OF THE USE OF X-RAY IN RADIOLOGY. BY MEDICINE. By Alan L. Hart, M.D. M.Sc. (Med). New York and London: Harper & Brothers, 1943.

# SURGERY

## GYNECOLOGY AND OBSTETRICS

*An International Magazine, Published Monthly*

VOLUME 77

OCTOBER, 1943

NUMBER 4

### STUDIES ON THE THERAPY OF HEMORRHAGIC SHOCK

#### I The Effects of Iso-Osmotic and of Concentrated Serum and Plasma in Normal Dogs

H NECHELES, M D, Ph D, S O LEVINSON, M D, MARTHA JANOTA, M S,  
R. E WESTON, M D, Ph D, and V WEISSMAN, Chicago, Illinois

TODAY, the rôle of decreased blood volume in the pathogenesis of shock or peripheral circulatory failure following surgical operations, tissue injury, burns, severe hemorrhage, and other conditions, is universally recognized. Although investigators disagree as to the mode of production of the oligemia, most of them agree that the impairment in the circulation due to the oligemia and to the consequent physiological compensations, in turn, leads to tissue ischemia, anoxia, capillary damage, and further loss of intravascular fluid through the damaged capillaries—the well known vicious cycle which leads to death (2, 17).

Modern therapy of shock has been directed toward interrupting this cycle by the rapid restoration of a normal blood volume. That transfusion of fresh whole blood could effectively restore the blood volume in shock was recognized early, but difficulties in typing, preservation, and storage of adequate amounts of citrated whole blood make this substance of limited application, even in civilian life. More-

over, abundant clinical and experimental evidence has established that, even in shock following severe hemorrhage, the important factor is the reduction in blood volume and not the loss of red cells (12).

During and after the first World War the search for adequate blood substitutes was greatly accelerated and it was conclusively demonstrated that any substance which is to maintain the circulation must restore the effective osmotic pressure of the plasma. That crystalloid solutions of various types and concentrations fail to correct the circulatory deficiency in shock soon became evident, in fact, with the increased permeability of the capillaries in shock these substances promote further loss of plasma proteins. Various colloids of different origin—acacia, pectin, animal proteins, etc.—have been proposed as blood substitutes but have not found wide or continued acceptance due to immediate or delayed toxic effects or to failure to maintain the circulation in shock.

The past few years have seen the simultaneous development by several investigators of a remarkably effective blood substitute—human plasma protein solutions in the form of serum or citrated plasma. When properly prepared,

From the Samuel Deutsch Serum Center and from the Department of Gastro-Intestinal Research of Michael Reese Hospital. This work was done under the auspices of the Committee on Research in Shock of Michael Reese Hospital and was supported by the Michael Reese Hospital Research Foundation.

these substances are reaction free and non antigenic and in their natural state are within the range of normal colloid osmotic pressure. Such iso-osmotic serum and plasma have been proved effective in the treatment of shock clinically and experimentally and have gained widespread use with excellent results.

More recently with the development of successful methods for the drying of serum and plasma, the use of hypertonic, and particularly four times concentrated solutions of human plasma protein has been advocated by some for the treatment of shock. Assuming that the increase in osmotic pressure of the blood following injection of these substances would reverse the mechanism of shock and lead to the restoration of the blood volume by withdrawing fluid from the tissues, these investigators (3, 5, 18) have advanced the use of hypertonic protein solutions because the smaller volume facilitated storage and transportation and permitted rapid administration of the solutions with a syringe thus circumventing the use and transportation of additional equipment.

Other investigators have failed to find any advantage in the use of concentrated plasma protein solutions in shock. Magladery, Solandt, and Best found iso-osmotic and concentrated protein solutions to be of equivalent value in the treatment of experimental post hemorrhagic shock. Brown and Mollison in a clinical survey reported several contra-indications for the use of four times concentrated serum. Mahoney, Kinguley and Howland reported that concentrated plasma had no prophylactic or therapeutic value in shock produced by intestinal stripping in dogs. Still others (6, 20) in surveying the use of blood substitutes in the treatment of shock have noted the fallacy of attempting to draw fluids from the tissues of a severely dehydrated patient.

In view of these conflicting reports and in view of the importance of this subject particularly to the armed forces, a decision as to the relative efficacy of iso-osmotic and concentrated plasma protein solutions is necessary. Under the conditions of modern warfare dehydration of combatants before or after injury is almost inevitable and it becomes necessary

therefore to evaluate the relative effects of iso-osmotic and concentrated plasma protein solutions in relation to the state of hydration of the individual.

Properly to compare the therapeutic efficiency of any proposed blood substitutes the following conditions should be fulfilled: (1) Unanesthetized animals and painless procedures should be employed in order to avoid the influence of the anesthetic and of pain and to permit an evaluation of the animal's clinical condition in shock and after infusion. (2) A method of producing shock must be employed which overcomes the variable resistance of individual animals to shock and which permits some means of relating the quantity of the therapeutic substance required to replace the fluid, cells and protein lost by the animal. (3) Properly prepared solutions must be used and these solutions must be administered in comparable amounts, at comparable rates, etc. (4) The state and degree of shock at the time of infusion should be carefully considered in judging the results from the therapeutic infusion. (5) Studies of survival time after therapy must be made.

We have endeavored to fulfill these conditions in a comparison of the effects of iso-osmotic and of concentrated plasma protein solutions on posthemorrhagic shock in both normal and dehydrated dogs. Shock was produced by graded bleeding, a procedure which is not unlike the blood loss suffered on the field of battle and which is known to deplete severely the body reserves of fluid (12). A preliminary report of this investigation has been presented (13). This paper is concerned with our findings in normal dogs; the subsequent two papers (11, 23) report the results in dehydrated dogs and the fluid, cell, and protein shifts before and after plasma protein infusions.

#### EXPERIMENTAL METHODS

Healthy mongrel dogs were deprived of food the day preceding the experiment but were permitted to drink water. In a typical experiment the right carotid and the right femoral arteries were cannulated, and the right and left femoral and the right external jugular veins were exposed under local pro-





free glassware tubing etc. were used throughout. The fourfold concentrated and many of the iso-osmotic, solutions were prepared by redissolving in sterile pyrogen-free water material dried by vacuum desiccation from the frozen state.

#### EXPERIMENTAL OBSERVATIONS

By graded bleeding all of the symptoms and most of the principal signs of shock can be produced. The typical response of the dog to this procedure has been described in detail in a previous publication (22) but the critical condition of many of the animals at the time the infusions were administered will bear further emphasis. With few exceptions, the small amounts of blood drawn for the post-hemorrhage chemical blood and plasma volume determinations aggravated greatly the condition of the animal. Generally this was reflected by corresponding changes in blood pressure, circulating times, and carbon dioxide values but, not infrequently the blood pressure variations bore slight relation to the actual deterioration of the animal's condition which was more accurately reflected by the level of the arterial plasma carbon dioxide content.

The animals which survived the posthemorrhage plasma volume determinations followed a steady downward clinical course. All untreated control animals died a short time after the last sample was drawn and only a few of the control animals which received infusions of either 0.9 per cent saline or 5 per cent dextrose in lactate-Ringer's solution in amounts greater than the total blood lost gave a favorable response. The degree of circulatory depression before the infusion can be seen from the posthemorrhage values for blood pressure, carbon dioxide, circulating time, plasma volume, and proteins, for all the normal animals. (An analysis of the fluid cell and protein shifts in posthemorrhagic shock before and after infusion will be found in the third paper of this series, 23).

Both iso-osmotic and concentrated infusions were administered to individual animals in different degrees of shock as represented by clinical appearance and objective experimen-

tal findings. In some dogs respiration had ceased and the cardiac impulse was imperceptible when the infusion was administered whereas at the other extreme there were animals in both groups in which the evidence of shock at the time of infusion consisted of weakness, blood pressure at shock levels increased circulation time and a moderately depressed carbon dioxide level. The condition of the animal at the time of infusion has an important bearing on its response to treatment (vide infra). A sufficient number of experiments were performed in order to obtain an equal number of animals in comparable degrees of shock in each group.

#### TREATMENT OF POSTHEMORRHAGIC SHOCK WITH ISO-OSMOTIC SERUM OR PLASMA

The immediate clinical response to infusion of iso-osmotic serum or plasma was striking in all 9 of the normal animals studied. Even a comatose animal in which respiration had ceased and the cardiac impulse was barely perceptible would exhibit striking improvement as soon as the infusion was begun. The heart beat and the blood pressure would rapidly improve to a degree that was almost proportional to the rate at which the solution was administered. Within a few minutes of the start of the infusion there would occur a spontaneous resumption of the respiratory movements and, by the end of the infusion, the animal would generally present an appearance which contrasted greatly with its previously moribund state. Often, the blood pressure would return to normal levels by the end of the infusion and in no case did it take it more than 10 minutes to reach the maximum level after infusion.

All of the animals except one (No. 5) were in good condition when removed from the table following the injection of the thioeyanate after the infusion. All could stand and walk, and most of them were quite active when placed on the floor. This good clinical condition persisted even after additional blood was removed 45 minutes later for the postinfusion chemical blood, and plasma volume determinations.

The clinical improvement was paralleled by the marked improvement in the laboratory

findings In nearly every case, the blood pressure returned practically to the control level before the bleeding Moreover, these animals, with the exception of the one noted, were well able to tolerate the additional bleeding required for postinfusion determinations so that at the completion of the experiment the blood pressures were maintained Circulating times in all animals returned to shorter than control values after the infusion, as has been reported previously (19)

The restoration of plasma volume and plasma protein after infusion was satisfactory in every case After the protein and fluid shifts which follow infusions had occurred and relative stabilization had taken place, the total circulating plasma protein was considerably above prehemorrhage values in every animal, the plasma protein concentration was within normal ranges in every animal, and the plasma volume was significantly greater than the control value in every animal but in No 8 in which it was equal to the control value The changes in red cell and total blood volumes were complicated by movements of red cells which apparently can be rapidly shifted into and out of the circulation The significance of the changes observed will be discussed in the third paper (23)

The arterial plasma carbon dioxide content seemed to be a better index of the degree of shock, response to therapy, and prognosis than were any of the other criteria This is demonstrated best by comparing the survival time after infusion with the carbon dioxide level at the time of infusion<sup>1</sup> If an arbitrary level of 15 volumes per cent is selected, it can be seen that all of the animals with pre-infusion carbon dioxide values above this level survived more than 24 hours On the other hand, only one animal (No 4) with a carbon dioxide content below this level survived for this length of time, 2 (Nos 6 and 7) survived 18 and 21 hours, and the rest survived through the experimental day and were found dead in their cages the next morning

Similarly, the recovery of the arterial plasma carbon dioxide content after infusion gave the best indication of prognosis for survival for, often, although blood pressure and cir-

culating time had returned to normal after infusion, the arterial plasma carbon dioxide content remained at low levels and the animal would be found dead the next morning The carbon dioxide recovery in all of the animals receiving iso-osmotic serum or plasma was good, when considered in relation to pre-infusion carbon dioxide levels

#### TREATMENT OF POSTHEMORRHAGIC SHOCK WITH CONCENTRATED SERUM

As others have noted (22), when concentrated or even iso-osmotic plasma was administered rapidly severe tetany or, sometimes, cardiac arrest occurred, evidently due to the lowering of the free calcium ion by the considerable amounts of infused sodium citrate No such effects were observed when concentrated or iso-osmotic serum was given at comparable rates For this reason the normal animals now to be discussed were given only concentrated serum

The response of the 11 normal animals receiving concentrated serum was decidedly poorer than that of the nondehydrated animals which received iso-osmotic plasma protein solutions Not infrequently, the rapidly administered concentrated solutions seemingly overburdened the circulation for, during and shortly after such infusions, there occurred a transient bradycardia and a drop in the diastolic pressure One animal (No 18), which was in an extremely critical condition at the time of infusion, failed to survive this additional insult and died within 5 minutes, after a temporary improvement in its circulation

Unlike the animals receiving iso-osmotic infusions, the animals receiving the concentrated solutions gave a delayed and often not very marked clinical response to infusion No improvement in the animal's condition could be observed for some time after the infusion, and often the animal's general appearance was not greatly changed despite a sustained elevation in the blood pressure Not many of these animals could stand and only a few of them could walk when they were removed from the table after the maximal blood pressure response to the infusion had been achieved

<sup>1</sup>See Table I in reprints of this paper

After a slight elevation due to the volume of the material injected the rise in the blood pressure was slow so that the maximal blood pressure response was not achieved for from 15 to 30 minutes after the injection of the concentrated serum. Although in 9 animals the blood pressure returned to levels usually considered above the shock level, in only 2 of these (Nos. 12 and 13) did the blood pressure return to within 20 millimeters of the control value before bleeding. Furthermore none of these animals were able to maintain these blood pressure levels later when blood was drawn for the postinfusion blood, chemical and plasma volume determinations.

This inability to tolerate loss of small amounts of blood was demonstrated also by the deterioration in the general condition of most of these animals at the completion of the final plasma volume determination. Even animals which subsequently survived more than 24 hours seemed moribund and comatose when returned to their cages at night, in contrast to the animals which received iso-osmotic solutions, nearly all of which could walk to their cages at the end of the day. Moreover the fact that 4 of the 10 animals which survived the initial effects of the concentrated infusion died within approximately 2 hours may be related, in part, to increased susceptibility to loss of blood.

The changes in blood pressure and clinical condition were reflected in part by some of the other experimental findings. In all animals but 1 (No. 15) there was an increase in the plasma volume after the injection of the concentrated serum; however in only 2 animals was the plasma volume elevated to values significantly greater than the control values, in contrast to the animals that had received isotonic serum. Despite some loss of intravascular protein following infusion both the circulating protein and the plasma protein concentration were well above the control level in most cases (23).

As in the group receiving iso-osmotic infusions the arterial plasma carbon dioxide level gave the best index of the degree of shock before infusion, the response to therapy and the prognosis. Four of the 5 animals with arterial plasma carbon dioxide contents

above 15 volumes per cent at the time of infusion survived more than 24 hours, and 10/55 hours; however in contrast to the animals which received iso-osmotic serum or plasma only 1 animal with a carbon dioxide below this level survived much more than 2 hours. The recovery of the arterial plasma carbon dioxide content after infusion was good in the 6 animals which survived more than 2 hours but was poor in 4 of the 5 which died within 2 hours of the injection of the concentrated material.

#### SUMMARY AND CONCLUSIONS

These results demonstrate that iso-osmotic plasma protein solutions are more effective in the treatment of posthemorrhagic shock in normal dogs than are concentrated solutions. The relative clinical improvement, restoration of blood pressure and plasma volume ability to tolerate further blood loss and survival times strikingly demonstrate the superiority of iso-osmotic over concentrated material.

The assumption underlying the use of four times concentrated plasma protein solutions in the treatment of shock has been that these solutions can increase the plasma volume as efficiently as larger amounts of iso-osmotic plasma or serum by elevating the intravascular osmotic pressure and thereby withdrawing fluid from the extravascular tissue spaces. However when as in these experiments there has been considerable external hemorrhage the extravascular reserves are greatly depleted as fluid shifts into the circulation in the early physiological compensations for the blood lost from the body. Consequently in many of our normally hydrated animals which received the four times concentrated material, despite the fact that after the infusion the blood pressure failed to return to prehemorrhage levels and the osmotic pressure (total plasma protein concentration) was above normal levels, the plasma volume recovery was poor in comparison with that of the animals which received comparable amounts of protein but additional fluid in the iso-osmotic material.

Moreover the possibility has been neglected that the gain in circulating intravascular fluid might be achieved at the expense of the intra-

cellular as well as the extracellular fluid, with added damage to tissues already injured by prolonged oligemia and anoxia. That the latter may be true is indicated by the poor survival times of the animals with arterial plasma carbon dioxide levels below 15 volumes per cent, at the time concentrated serum was injected. Despite the increase in plasma volume, these animals exhibited slight clinical improvement and poor survival times when compared with those which received iso-osmotic solutions. Since the main premise in the treatment of shock is the restoration of circulating plasma volume, the administration of concentrated solutions in shock from repeated or prolonged hemorrhage does not seem to be a physiologic procedure.

These results demonstrate that in the treatment of shock produced in animals by graded bleeding, a procedure which severely depletes the body reserves of fluid, concentrated plasma protein solutions are inferior to iso-osmotic solutions. It is to be expected, therefore, that the treatment of hemorrhagic shock with such concentrated solutions would be even less effective in animals which have been dehydrated by withholding of water before the experimental hemorrhages (11).

# REFERENCES

- 1 ANDERSON, F F J Lab Clin M, 1941, 26 1521
- 2 BLALOCK, A Principles of Surgical Care, Shock and Other Problems St Louis C V Mosby Co, 1940
- 3 BOND, D D, and WRIGHT, D G Ann Surg, 1938, 107 500
- 4 BROWN, H A, and MOLLISON, P L Brit M J 1940, 2 821
- 5 COHN, E J Reported at Human Serum Association, Cleveland, 1941 MUDD, S, and THALHEIMER, W Blood Substitutes and Blood Transfusion, Springfield, Ill C C Thomas, 1942
- 6 Conference on Therapy Cornell U Medical College, N York State J M, 1942, 42 1480
- 7 CRANDALL, L A, JR, and ANDERSON, M X Am J Digest Dis, 1934, 1 126
- 8 GIBSON, J G, and EVANS, W A JR. J Clin Invest, 1937, 16 301
- 9 GOODNER, K, HORSFALL, F L, and DUBOS, R J J Immunol, 1937, 33 279
- 10 KINGSLEY, G R J Biol Chem 1940, 133 731
- 11 LEVINSON, S O, JANOTA, M, WESTON, R. E, and NECHELES, H In press
- 12 LEVINSON, S O, NEUWELT, F, and NECHELES, H J Am M Ass, 1940, 114 455
- 13 LEVINSON, S O, WESTON, R E, JANOTA, M, and NECHELES, H Surgery, 1942, 12 878
- 14 MA, T S, and ZUZAAGA, G Indust Engin Chem, Analytical Edition, 1942, 14 280
- 15 MAGLADERY, J W, SOLANDT, D Y, and BEST, C H Brit M J, 1940, 2 249
- 16 MAHONEY, E B, KINGSLEY, H D, and HOWLAND, J W Surg Gyn Obst., 1942, 74 319
- 17 MOON, V H Shock Its Dynamics, Occurrence, and Management Philadelphia Lea & Febiger, 1942
- 18 MUTRHEAD, E E, ASHWORTH, C T, and HILL, J M Surgery, 1942, 12 14.
- 19 OLSON, W H, GUTMANN, H, LEVINSON, S O, NECHELES, H War Med, 1942, 1 830
- 20 RAVITCH, M M, and BLALOCK, A. Surg Gyn Obst., 1942, 74 348
- 21 VAN SLYKE, D D, and NEILL, J M J Biol Chem, 1924, 61 523
- 22 WESTON, R E, JANOTA, M, LEVINSON, S O, and NECHELES, H Am J Physiol, 1943, 138 450
- 23 WESTON, R E, JANOTA, M, NECHELES, H, and LEVINSON, S O In press

# A NEW OPERATIVE APPROACH TO THE KNEE JOINT

KENNETH COONSE, M.D. F.A.C.S. and JOHN D. ADAMS, M.D. F.A.C.S.

Boston, Massachusetts

**I**n the ordinary type of incision used in exploration of the knee joint, be it of the lateral roedial, or combined type visibility is usually inadequate and only accomplished by forceful retraction of the knee joint tissues. The incision here described has afforded excellent visibility of all knee joint structures, and we believe it to be the only surgical approach permitting satisfactory open reduction of intra-articular fractures of the knee joint. In addition to the virtue of simplicity of approach and repair it reduces to a minimum the necessity of retraction

## OPERATIVE TECHNIQUE

The usual type of paramedian skin incision is used, beginning at the lower end of the quadriceps muscle near the beginning of the tendinous portion, swinging either medially or laterally along the edge of the patella and the patellar tendon. The skin is then dissected from the patella. The quadriceps tendon is split down the middle beginning at the upper end where the tendinous portion joins the muscle. At a point about one-quarter to one half inch above the upper portion of the bony patella, the incision is swung both medially and laterally continuing about the same distance from the patella down along the patellar tendon. One usually encounters a small bleeder in the fat pad at this point which is readily controlled by ligature. The patella and patellar tendon drop downward thus affording a complete exposure of the joint. When the sides of the patellar tendon are retracted medially and laterally respectively the entire lower end of the femur and quadriceps pouch are readily exposed. By acute flexion of the knee complete visualization and palpation are possible.

In closure, the knee is extended and the patella pulled upward into its normal position. This permits the line of incision to come together without the slightest tension. One or two anchor sutures of fairly heavy Deknatel

silk are taken at the point where the patella joins the two halves of the quadriceps tendon. The quadriceps tendon and the edges of the patellar tendon are sutured together with heavy chromic catgut, following which the line of suture is tested by acute flexion of the knee. The fascia and skin are closed in the usual fashion without drainage.

*Postoperative care.* A ham splint is ordinarily applied at the time of operation and quadriceps setting exercises are carried out hourly as soon as the patient recovers from anesthesia. On the 7th or 8th postoperative day the ham splint is removed the wound is dressed, an ace bandage is applied and active functional use without weight bearing is allowed. Quadriceps setting exercises are continued throughout the convalescent period. On the 10th to 14th day weight bearing is allowed with the use of crutches. In from 3 to 4 weeks the patient should be ambulatory without the use of a cane or crutches. Sutures are usually removed at the end of 2 weeks and the incision is strapped with flamed adhesive.

*Discussion of procedure.* This operative approach to the knee joint obviously affords numerous advantages over the ordinary type of incision. It enables one to obtain complete visualization of the knee joint structures with a minimum of trauma and a maximum of exposure. Thus, in the case of transverse or T fractures near or into the joint, accurate approximation of the joint surfaces may be obtained. With this exposure drilling and bolting of the fragments are accomplished with relative ease. In bolting the fragments it is wise to place the bolts posterior to the quadriceps pouch. This is readily accomplished by opening the quadriceps pouch posteriorly drilling the necessary holes bolting the fragments and then suturing the posterior layer so that the bolts are actually posterior to the knee joint proper. This complete exposure enables one to visualize all abnormalities of the knee joint including internal derangements

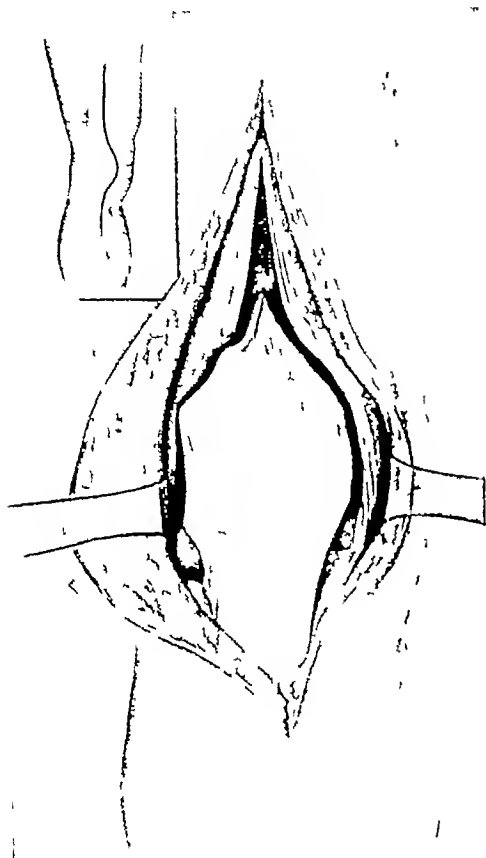


Fig 1 The skin incision is shown in the insert. Large drawing shows incision carried through quadriceps tendon along each side of the patella and the patellar tendon. Following this the knee is flexed (see Fig 2)

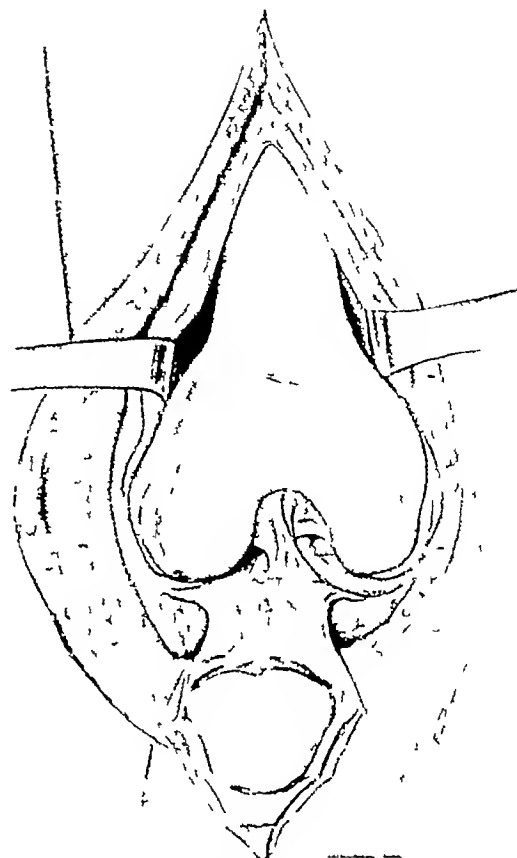


Fig 2 The extent of exposure of knee joint and lower end of femur when knee is flexed and patella is allowed to drop downward. Note the extent of visualization of lower end of femur, cruciate ligaments, and cartilages

such as injuries to the cartilages, torn cruciate ligaments, joint mice, arthritis, and other pathological changes such as osteochondritis dissecans. We particularly wish to emphasize that this incision practically eliminates the need for retraction and thereby minimizes trauma to the knee joint structures. Convalescence in the operative cases has been unusually rapid with relatively little discomfort.

#### CASE REPORTS

A summary of four cases follows

**CASE 1** M C, female, aged 70 years. Patient stated that while outdoors on the afternoon of February 6, 1942, she slipped on the wet pavement and fell forward to the ground onto her hands and knees. In trying to get up from the sidewalk, she fell

again, this time falling sharply onto her right knee, and she was unable to get up. She was assisted to her feet but her right knee was extremely painful and she was unable to move it. She was then assisted home and was brought to the hospital by the house ambulance. Patient was admitted to the ward after having been seen in the plaster room where a long leg cast was applied with no attempt at reduction. Closed reduction was attempted on February 9, 1942, and x-ray films showed still some displacement of fragments. On February 19, 1942, open reduction with fixation of the lateral condyle by means of two metal bolts and nuts was done. Patient was returned to the ward and the leg was suspended in balanced overhead suspension. X-ray examination on February 25, 1942, showed good position. On March 4, 1942, all sutures were taken out and the wound was clean and healed. On March 9, 1942, balanced suspension was removed and on March 13, 1942, patient was up and about on crutches with no

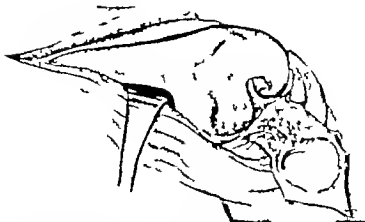


Fig. 3. A semilateral view of the joint. The simplicity of bolting or plating fractures of the lower end of the femur is shown. With this location very little retraction is required.

eight bearing. Patient was discharged on March 4, 1943 on crutches (thirty-eight bearing).

**Operative note.** Under general anesthesia, with a tourniquet about the right upper thigh, the leg was prepared with 5 per cent iodine and draped with the extremity free. A 7-inch incision was made on the anterior aspect of the lower femur and knee joint in the midline. After the skin and subcutaneous tissues had been retracted, a Y-shaped incision with the stem pointing proximally was made in the quadriceps tendon. This allowed the patella to be turned down distally. The quadriceps muscle was then stripped up from the lateral condyle for about one-half its width. The fragment was opposed to the main shaft fragment and two bolts were inserted through drill holes and nuts applied on the medial aspect. The articular cartilage in the joint was not exact, anatomical but the position was good. The wound was then sprinkled with about 3 grams of sulfanilamide crystals and the Y incision in the quadriceps tendon closed with No. 2 chromic catgut continuous suture. Several interrupted sutures were taken also. The subcutaneous tissue was closed with fine plain catgut and the skin closed with running black silk suture. Postoperative condition was excellent. Patient returned to the ward and put in Thomas splint with Pearson attachment.

On February 8, 1943 patient stated that she was able to carry on all her normal activities and had no symptoms referable to the right knee. She did not limp. Examination at this time showed that the incision was well healed. She had complete extension. Both knees appeared symmetrical. She had flexion to about 4 degrees beyond the right angle. Increased anteroposterior mobility and she had no appreciable increase in lateral mobility. There was slight amount of thickening. The suprapatella on the right was 4 inches upper border of patella

4 1/2 inches, and lower border 13 inches and patella on the left was 14 inches upper border of patella 14 inches and lower border 13 1/2 inches. There was some creaking in both knee joints not any more perceptible on the right than on the left.

**CASE HISTORY.** Male aged 38 years. Patient admitted to Beverly Hospital March 1, 1943. His chief complaint of "bad knee of 1 year" duration. He has always been in good health except for asymptomatic lues discovered by positive serology on routine blood examination year ago. At about this same time patient first began to complain of weakness and pain in the right knee, most marked at lateral aspect of the knee, at the edge of the patella. The knee could occasionally give way during ordinary walking but patient has never fallen. There has been no swelling or marked tenderness at any time. Arch supports gave some relief although pain and weakness persisted steadily up to present time. X-ray films showed question of fracture or bipartite patella.

Examination showed no relaxation of the quadriceps tendon or increased lateral mobility of the joint itself. Full flexion was possible but it was limited to

thirty degrees of full extension and caused some discomfort under the patella itself. There was no capsular thickening and no especial tenderness over either semilunar area. There was very slight amount of crepitus in the joint on motion. Inasmuch as this patient had not responded to any of the conservative measures it was thought advisable to explore this knee.

On March 9, 1943 exploration of the right knee with the incision described showed fibrous fat pad which was removed in part. Nothing abnormal could be found in the joint. This patient made uneventful recovery and left hospital eight weeks following operation.

CASE 3 R A C, male, aged 18 years In October, 1941, patient was struck in the left knee while playing football The knee swelled a good deal It would snap out of joint and then back again In December, 1941, he bent down to pick up some object and could not straighten out the knee He was then taken to the Boston City Hospital A cast was applied and he went home the same day Cast was on 3 weeks Went to Boston City Hospital clinic several times Three weeks ago was seen at the Boston Dispensary

On February 27, 1943, operation as described was done A very large cystic semilunar cartilage about the size of a small English walnut was removed It was attached only by the posterior horn It would have been impossible to have delivered this and taken it out in entirety through the ordinary parapatellar incision As usual, a posterior ham splint was applied He had a perfectly uneventful convalescence Wound was clean and stitches out

On March 8, 1943, this boy was taken with acute pain in his side and on investigation vomited some blood He unquestionably had a pulmonary infarct This all cleared up by March 22 and the boy was up and around on crutches Convalescence was obviously prolonged through the complication of the infarct He had been carrying on his splinting of the quadriceps group of muscles On this date, the knee went to full extension and to right angles and apparently there was no weakening of the quadriceps group On April 1 the boy was around without crutches He had practically no limp Knee went to beyond a right angle to full extension He had less than three quarters of an inch of atrophy through the thigh with good quadriceps power He had been working actively on his feet 2 days that week

CASE 4 F B male, aged 42 years Patient stated that on January 15, 1943, about 7 a m he slipped on the ice while at work and fell, twisting his left knee He stated that the knee had been splinted and bandaged until about February 11 He said that he had had previous fractures of both bones of the right lower leg

Examination revealed mild, nontender swelling in the infrapatellar region There was a very mild defect in complete extension and there was a mild restriction in flexion accompanied by complaint of pain There was no abnormal mobility present and there was no pain complained of on testing for this The musculature of both legs, upper and lower, was very light but there was no apparent atrophy of the left leg

On examination on March 10, 1943, he had a very slight amount of increased joint fluid which was readily demonstrable in a standing position He had fairly acute tenderness along the internal semilunar cartilage, particularly near the internal lateral ligament Extension lacked about 5 degrees and any attempt to force extension produced discomfort re-

ferred to the medial side and back of his joint Flexion lacked possibly 5 degrees and external rotation produced discomfort over the medial cartilage region Internal rotation produced only mild discomfort There was no increase in anteroposterior or lateral mobility in either flexed or extended position

Operation was done on April 8, 1943 Under spinal anesthesia, a tourniquet was applied to the left thigh The field was prepared and draped in the usual fashion A routine skin incision was made and the skin isolated A quadriceps splitting incision was carried along both sides of the patella The knee was flexed and the medial cartilage found to be loose in its posterior third This was excised The external cartilage appeared to be normal in position and relationships Routine inspection of the joint revealed no other pathology The wound was closed in the usual fashion with three Deknatel silk sutures The balance of the incision was closed with chromic No 1 catgut, silk to the skin Sterile dressings and ham splint were applied Postoperative course to date has been uneventful with remarkable freedom from postoperative pain

#### SUMMARY

A new operative approach to the knee joint is herein described which we feel has numerous advantages as compared with the various standard incisions now employed

- 1 It affords maximum exposure with a minimum of retraction

- 2 Because of the ease of retraction, there is relatively little trauma to knee joint structures

- 3 The incision is relatively avascular (the only vessel encountered being in the fat pad near its lower portion)

- 4 It is the only incision with which we are familiar which enables one to secure a surgical approach and adequate treatment of fractures in and about the knee joint

- 5 The exposure is ideal for synovectomy

- 6 It is an excellent exposure for arthrodesis

- 7 In our experience it is the only type of operative approach and repair which will permit acute flexion of the knee (prior to skin closure) without separation of the line of suture

- 8 We wish to emphasize particularly that there has been no demonstrable weakness or impairment in function of the quadriceps following operative repair although the ages in the reported cases ranged from 18 to 70 years



# A STUDY OF THE SMALLER BLOOD VESSELS IN BURNED DOGS AND CATS

RICHARD G. ABELL, Ph.D. and IRVINE H. PAGE, M.D. Indianapolis, Indiana

ANIMALS which have been seriously burned exhibit many of the signs which accompany shock produced by limb tourniquets and by allowing plasma to escape from peritoneal surfaces. Page and Abell found (5) that arteriolar vasoconstriction was one of the most characteristic hemodynamic changes accompanying tourniquet shock and that this was present both in the mesenteric vessels of cats and the peripheral vessels of the rabbit's ear. Further it has been shown by Page (3) that the plasma of dogs in shock from tourniquets, hemorrhage and from burns assumes vasoconstrictor properties when studied in the perfused rabbit's ear preparation. It naturally followed that vasoconstriction might be found in burned animals as well. If this were so it would present a more unified picture of a part of the mechanism of shock produced by or associated with, these diverse methods.

To our surprise we have not found in the literature any study which is more than very casual concerning the state of the blood vessels after burns. Since the method of Zintel for observation of the mesenteric vessels as developed in Clark's laboratory is so well adapted to studies of this kind we have used it and the results are the subject of this paper.

## METHODS

The methods employed have been essentially the same as those we used for the study of shock (5). The dimensions of the chambers for the cats were the same as given by Zintel. A chamber resembling the Zintel chamber but larger was designed for dogs. In it the channel for the intestine was 20 millimeters in diameter which was found to be adequate for the largest dogs used in these experiments (14 kilograms).

From the Department of Anatomy, Medical School, University of Pennsylvania, Philadelphia and the Lilly Laboratory for Clinical Research, Indianapolis City Hospital, Indianapolis, Indiana.

In all of the cats the body wall at the site of the incision was sewn tightly into the flanges of the chamber. This was done also in 5 of the dogs. In the remainder the chamber was stitched loosely to the skin, in order to avoid movements due to respiration. In previous experiments the chambers were inserted into a midline incision. This was done in 4 of the cats and 5 of the dogs in these experiments. In the remaining animals a right rectus incision in the right lower quadrant was used which was found to be more satisfactory when the chambers were held horizontally, especially in the case of the dogs.

Most of our observations were made with the chamber held rigidly in a horizontal position. The vessels were studied at magnifications of from 22 to 400 diameters.

The portions of the gut used were the jejunum and ileum.

Arterial pressure was measured by direct carotid arterial cannulation. The anesthetic was pentobarbital (30 mgm. per kgm. of body weight). The clipped legs of the animal were burned by immersing them in boiling water for about 2 minutes. In 2 animals the burn was inflicted by live steam from a funnel.

The larger arteries studied had control diameters of from 0.2 to 1.5 millimeters and the smaller arteries from 0.024 to 0.066 millimeter. The larger veins had diameters of from 0.3 to 2.1 millimeters and the smaller ones from 0.03 to 0.14 millimeter.

## OBSERVATIONS

**Control.** In 6 dogs the vessels were observed for periods of 6 to 1 hours to ascertain what changes if any occurred spontaneously. The variations that can be expected are: (1) larger arteries—no narrowing at all or in some cases narrowing to about 0.8 the control diameters; (2) smaller arteries—no change at all or in some instances narrowing to about 0.9 of the control diameters; (3) larger veins—no change

at all or in some cases narrowing to about 0.8 of the control diameters, (4) smaller veins—in some cases slight widening or narrowing. The flow of blood changes insignificantly. Similar results were secured with 3 cats observed for periods of 3 hours before burning. The capillaries were all open and none were constricted, as seen not only in the mesentery, but also in the wall of the gut itself.

**Experimental.** Fifteen dogs and 5 cats were used for the experiment. Within 10 to 90 minutes the larger arteries began to constrict. There was progressive constriction reaching a maximum in about 2 hours. The degree of constriction was usually to 0.3 to 0.6 the control diameters. Such constriction is shown in Figures 1 to 4.

The smaller arteries also constricted in about the same manner, as shown in Figures 5 to 8. The degree was usually to 0.2 to 0.6 the control diameters (Tables I and II). Such constriction began well before fall in systemic pressure. In some cases arterioles having control diameters of 24 microns were seen to constrict to the point of cutting off the blood flow (see A3 and A4 of Table I). The same type of constriction was observed in the arteries of the intestine. A short time before death the arteries not infrequently relaxed somewhat, but never beyond the control diameters, and usually not that much (cf. A2 and A3 of Table II).

The smaller veins did not constrict appreciably, possibly in the cats there was a slight narrowing, but in the dogs there was frequently slight dilatation toward the end of the experiments.

The larger veins usually became markedly narrowed. In some of them a series of constrictions produced sausage-shaped segments which changed from time to time. As confirmation of the vasoconstriction it was observed that the mesentery became distinctly blanched and the gut bluish. The tongue of the animal simultaneously assumed the same color.

The rate of blood flow always decreased, beginning in some experiments within 10 minutes and in others not for an hour or two. The flow diminished progressively until there was frequently little or no movement of the cor-

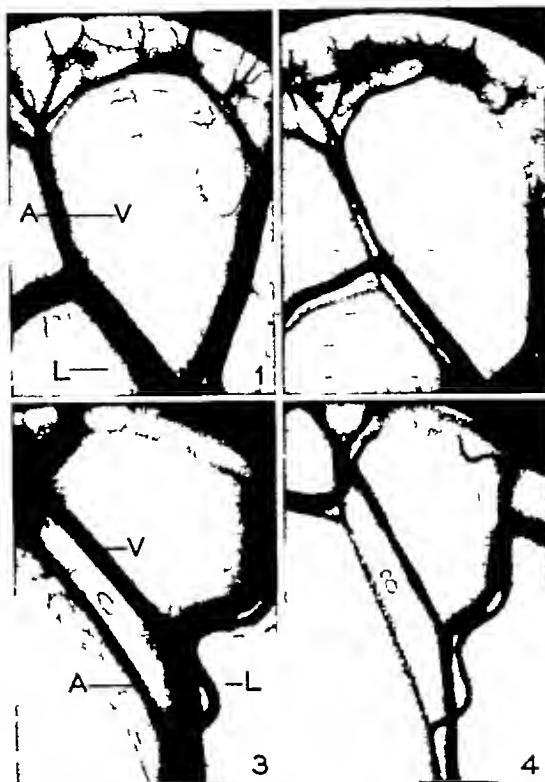


Fig. 1. Control. Photograph showing the appearance of the larger vessels of the mesentery of cat 3, before burning. A, artery, V, vein, L, lymphatic.  $\times 2$ .

Fig. 2. The same vessels 1 hour after the legs were placed in boiling water for 2 minutes. Note vascular constriction. Observations at this time showed much reduced blood flow.  $\times 2$ .

Fig. 3. Control. Photograph showing the appearance of the larger vessels of the mesentery of cat 5, before burning. A, artery, V, vein, L, lymphatic.  $\times 2$ .

Fig. 4. The same vessels 4 1/4 hours after the right hind and front legs and side were burned with live steam. Note vascular constriction. The blood flow at this time was much reduced.  $\times 2$ .

puscles in the smaller arteries and veins or in the capillaries. Stasis was not uncommon in many of the capillaries and venules half an hour to an hour before death.

The capillaries, especially in the cat's mesentery, were very clearly seen. The endothelial walls were visible and the endothelial nuclei as well. We were unable to see any significant change in the diameter of the capillaries after burning in the 5 cats examined. Especially there was no opening up of constricted capillaries since control observations showed no constricted capillaries.

TABLE I.—THE EFFECT OF STEAM BURN OF THE LEGS AND BODY UPON THE DIAMETERS OF THE SMALLER AND LARGER ARTERIES AND VEINS OF THE MISENTERY OF THE DOG

Smaller vessels—diameters in millimeters

Time	A <sub>1</sub>	V	A <sub>2</sub>	V	A	V	A <sub>1</sub>	V	A V A	S P mm Hg
15—	07	04	07	06	014	30	14	008	0.014	120
15—	Steam burn, small areas at time									
20	07	06	07	08	004	030	044	030	000	144
27	07	20	07.2	10.0	004	030	000	15	000	14
27	018	20	01.3	10.0	009	30	000	0.17	000	20
30	0.040	30	0.04	10.0	000	040	000	0.17	000	14
4 30	30	30	0.04	10.0	000	030	000	04.3	000	14
75	044	00		10.0	000	040	000	0.17	000	100

Larger vessels—diameters in millimeters

	A	A <sub>1</sub>	
20 m	00	00	00
2 30— 35	Steam burn		
4 12	0.04	04	00

A<sub>1</sub>, A<sub>2</sub>, etc., arteries, V, etc., veins, A-V-V, arteriovenous anastomosis. The dog was sacrificed at 70 m. Autopsy showed primary hemorrhages in the subcutaneous of the left tibia, the veins of the left tibia, massive hemorrhages in the spine, hemorrhages and edema in the stomach area.

TABLE II.—THE EFFECTS OF BURNS OF THE LEGS UPON THE DIAMETERS OF THE LARGER AND SMALLER ARTERIES AND VEINS OF THE CAT'S MISENTERY

Larger vessels—diameters in millimeters

Time	A <sub>1</sub>	A <sub>2</sub>	V	V	V	S P mm Hg
14 m		1.3	30	30	60	100
20— 47	legs burned					
		0.16		25	30	44
		1.4			30	1
20	00	1.4	0.1	15	30	44
5 30	00	0.1			47	47

Smaller vessels—diameters in millimeters

Time	A <sub>1</sub>	V	A	V	A <sub>2</sub>	
30 m	0.14	030	0.038	040	30	0.13
40— 47	legs burned					
30	00	030	00	0.04	030	0.04
48	0.13	0.08		0.08	0.14	0.13

The legs were burned by placing in boiling water five minutes. The cat died at 48 m. Autopsy showed small hemorrhages in the mesentery, small hemorrhages in the subcutaneous of the left tibia and vein in the right tibia, hemorrhages of the lungs.

In 3 dogs and 2 cats the lymphatics were measured in one of the dogs narrowing occurred to 0.7 of the control diameter after burning in the second to 0.5 but in the third no change was observed. In one dog the rate of flow in the lymphatics was measured by the

movement of white corpuscles. Before the burn it was 57 microns per second. Two and one-half hours later it had increased to 83 microns per second. Fifteen minutes before death it had become much faster but the rate was not measured. In the cats the lymphatics

narrowed to about 0.4 to 0.7 their control diameters (cf Figs 1 to 4)

The blood plasma developed vasoconstrictor properties as measured in the perfused rabbit's ear preparation of Page (4) in all of the animals so tested (3 dogs)

Arteriovenous anastomoses were observed to constrict shortly after burning and not infrequently before the parent vessels. The effect was to cut off the shunt, so decreasing the venous return to that extent

The area burned was greater in the animals exposed to steam than in the others and the amount of edema was greater. In these animals, in addition to the things described, the erythrocytes in the smaller venules became packed tightly against each other and against the vessel walls (cf Fig 9). The blood moved forward slowly and with difficulty at this time, in many venules it stopped abruptly during expiration and moved forward only slowly during inspiration, as though its viscosity were abnormally great. Little or no plasma could be seen between the erythrocytes themselves or between them and the venule walls, a striking contrast with the control condition. When movement was present the appearance was that of a material of high viscosity being pushed along with difficulty.

The erythrocytes not only became abnormally crowded in the venules in the animals burned with steam, but they also stuck to each other. In consequence the blood moved forward as a solid column of cells, or when this became broken, as clumps of erythrocytes which were pushed through the vessels with difficulty and not infrequently got stuck.

Normally, a leucocyte stuck to the wall of a venule has no pronounced effect upon the blood flow, since the erythrocytes in the plasma readily slip around it and do not adhere to each other. But in these instances, when the erythrocytes were crowded together and stuck to each other, and the venules tightly filled with them, even a single leucocyte stuck to the wall impeded and frequently stopped the flow.

Hematocrit determinations showed marked hemoconcentration after the animals were burned with steam. For example, in one dog the percentage of erythrocytes in the blood

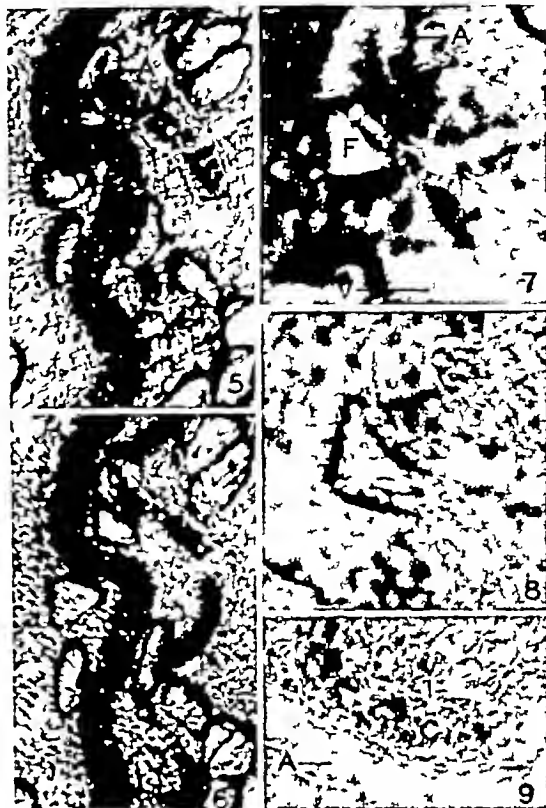


Fig 5 Control Photomicrograph of two of the smaller vessels of the mesentery of cat 5, before burning. The actual diameter of this arteriole was 40 microns. A, arteriole, V, venule, F, fat cell  $\times 120$

Fig 6 The same vessels 2 hours after cat was burned with steam. Note arteriolar constriction, blood flow much reduced.

Fig 7 Control Photomicrograph of a portion of the same arteriole and venule as in Figure 5, but at higher magnification. The letters A, F and V are in the same relative positions as in Figure 5  $\times 240$

Fig 8 The same vessels as in Figure 7, 2 hours after cat was burned. Arteriole is constricted, blood flow reduced.

Fig 9 Photomicrograph of an arteriole, A, and venule, V, in another portion of the mesentery of cat 5 2 1/2 hours after the cat was burned. The venule contains blood cells (C) packed tightly together and against the sides of the vessel, so that the walls are not clearly visible. The line from V ends on one wall of the venule. There is no flow of blood in this vessel, as shown by the absence of a blur such as seen in the arteriole. This lack of flow was caused in part by the marked hemoconcentration  $\times 240$

increased from a control of 42 to 65 within half an hour after onset of the burn.

#### EVALUATION OF STUDY

The response of the vascular system to burns seems to be almost identical with that ob-

served by us in shock produced by tourniquets obstructing the flow of blood to the limbs. The irregular constriction of the veins was not seen in the latter nor was stasis of blood in the mesentery or concentration of corpuscles within the vessels. In this latter connection it should be noted that hemoconcentration was marked in the present experiments, where as in the previous experiments it was only moderate. Arterial constriction in the present experiments was also somewhat greater so that the blood flow was consequently more reduced. The previous experiments dealt with cats. Recently we have put into shock by incomplete occlusion of the limb circulation 4 dogs containing intestinal-mesenteric chambers, and in these cases not only was marked reduction of flow observed in the mesentery as in the cats but also stasis in some of the capillaries and venules shortly before death.

Just as in shock produced by tourniquets, vasoconstriction caused by burns begins well before systemic arterial pressure starts to fall. The result is progressively diminished flow of blood to the periphery and reduced return to the right heart. Adding in this reduction is the cutting off of the arteriovenous anastomoses, and in cases of marked hemoconcentration increased viscosity of the blood. Because of their high reactivity (Clark and Clark) it is to be expected that arteriovenous anastomoses should close rather abruptly following burns.

It cannot be said with certainty that the changes observed in the mesenteric vessels will be the same as those in peripheral vessels such as those of the ear. Previous experience however indicates that arterial constriction with reduced flow in the one will be reflected in the other. The bluish-red cyanotic hue which develops in the intestine as the result of vasoconstriction and hemoconcentration is paralleled by similar change in color of the tongue. We believe that cyanosis of the intestine can be predicted from the color of the tongue in dogs.

The sticking of erythrocytes to each other such as described in the present experiment was recently reported in dogs during traumatic shock by Knusel. Since it has been shown (Page 3) that the plasma of burned

animals acquires vasoconstrictor properties it seems reasonable to relate this to the vasoconstriction we have observed in these experiments. However no attempt was made in the present experiments to separate the effect of such humoral factors from possible nervous ones nor can we be sure how much of the narrowing of the vessels is passive due to decreased blood volume.

It appears that release of a substance which causes vasoconstriction, without augmenting the force and output of the heart must inevitably lead to diminished return of blood to the heart and failure of the peripheral circulation. The opposite of this hemodynamic picture was recently encountered in one of our patients (Page Kohlstaedt and Taylor 6). The man had taken arsenic for suicidal purposes. Despite the fact that arterial pressure fell to about 38 millimeters mercury mean pressure in the recumbent position, he felt well and was able to rise and walk without difficulty. Flow to the peripheral tissue was not appreciably reduced. The explanation for his lack of symptoms appears to have been that the output of the heart was nearly tripled and peripheral resistance fell to a very low value a picture quite the opposite of shock.

#### SUMMARY

- 1 Burns produced in dogs and cats by hot water or steam are associated with the occurrence of severe vasoconstriction in the larger and smaller arteries and the larger veins. In dogs the smaller veins either remain unchanged or dilate slightly. In cats they do not change appreciably or may become slightly narrowed. Irregular constriction in the larger veins occurs in roughly a fourth of the animals. No change in diameter was seen in the capillaries.

- 2 Arteriovenous anastomoses constrict after burning, so adding in reducing the return flow to the right heart.

- 3 Vasoconstriction occurs before fall in systemic arterial pressure is observed.

- 4 The rate of flow of blood decreases sharply after burning and continues to diminish with the passage of time. Frequently stasis develops in many of the capillaries and venules half an hour to an hour before death.



# ATRAUMATIC AMPUTATION THROUGH THE LOWER THIGH

## Experiences with Its Use in Peripheral Vascular Disease

FELIX PEARL, M.D., and MAURY MISRACK, M.D. M. J. for M.C., U.S.A.,  
San Francisco, California

**A**BOUT 12 years ago we awakened to the shocking mortality of amputation for chronic occlusive peripheral vascular disease and aware of the lack of satisfactory criteria for the conduct of the serious complication of such affections, one of us began to give special attention to disorders of the peripheral vessels and established the Clinic of Sympathetic and Vascular Surgery for purposes of study. It is the general rule that as soon as cases of peripheral vascular disease in any institution are placed under the care of men especially interested and trained in their conduct, the results at once begin to improve.

In the majority of cases in which removal of a portion of the lower limb was necessary amputation was done above the knee. The operation was performed by the usual "tendoplastie" technique until 1935 when Callander (1) reported his technique for supracondylar thigh amputation which cut through no muscle bellies. This technique was considered especially suitable for cases of peripheral vascular disease for the following reasons: (1) no tourniquet is used (2) the natural barrier to infection formed by the fascia of the popliteal space is preserved (3) no muscle bellies are cut (4) long viable skin flaps may be fashioned from the upper leg (5) the closure includes only skin and subcutaneous tissue is affected without tension and allows ample room for drainage (6) the stump is long mobile and end-bearing (7) operative shock is minimal and (8) the patient may be allowed in a chair on the first day after operation.

The operation was so satisfactory that it was adopted as the routine lower thigh amputation in the clinic. After performing 15 amputations according to the original tech-

nique one of us (F.L.P.) modified the procedure in an attempt to improve the results. The reasons for and the nature of the modification have been set forth elsewhere (12). The present report deals with our results in 36 amputations for peripheral vascular disease performed by the basic technique which cuts no muscle bellies—15 cases by the original Callander operation and 21 by the Pearl modification. Whereas our series is small, it was our opinion that our experiences with a comparatively new amputation were worth reporting.

### GENERAL CONSIDERATIONS

It is not the authors' intention to enter deeply the controversies regarding indications for treatment of vascular disease and its complications sites and times for amputation or other subjects on which well informed surgeons have honest differences of opinion. Certain points, however, should be emphasized.

The proper surgical treatment of infection, ulceration or localized gangrene in any extremity which is the site of peripheral arterial disease depends to a great extent on the circulatory balance of the extremity. If the arterial circulation is competent, local operation may be done under certain circumstances. If incompetent, such surgery is always contraindicated. It is a matter of mere surgical judgment based upon special training and experience in estimating the circulatory balance as to when local surgery is allowable. The cold pulseless foot which blanches on elevation and becomes erythromelic on dependency will not stand the additional insult of surgical trauma. Yet the absence of pulses alone does not contraindicate local operation if the foot is warm and shows no postural color changes. Surgery performed on feet with

From the Clinic of Sympathetic and Vascular Surgery Mount Zion Hospital.

incompetent circulation is not only meddlesome, the delay entailed and the lowering of local resistance invites the onset of spreading infection which may overwhelm the defenses of the patient's blood stream before even high amputation can come to his rescue. It is well recognized that uncontrolled diabetes greatly accentuates the liability of spreading infection. Its presence must always be ascertained. Diabetes properly controlled before, during, and after surgery adds no great danger to the operative procedure, yet other things being equal the controlled diabetic surely has not the resistance to surgical trauma that one finds in the nondiabetic.

#### INCOMPETENT CIRCULATION WITHOUT INFECTION

The ulcerated or gangrenous extremity, which after careful examination is judged to have an incompetent arterial circulation, is treated conservatively for from 3 to 4 weeks in the hospital as long as there are no signs of spreading infection. If there is no satisfactory improvement, amputation should then be considered. It is useless and dangerous, as well as economically wasteful, to prolong conservative treatment past the time when improvement is obviously not going to take place. The lesion may be relatively free of infection so that amputation may be delayed with little additional risk, but once cellulitis or lymphangitis has occurred, the patient should be urged to accept the inevitable. The surgeon must squarely face the amputation issue and communicate his mature unequivocal decision to the patient, despite the natural abhorrence which we all feel toward mutilation. Some surgeons share that "I would rather be dead" attitude expressed by patients who are face to face with the amputation dilemma, yet the attendant's duty to prolong life is clear-cut, even when an extremity must be sacrificed. Often he must disregard the wishes of the family for nonintervention when the patient's own desire is to submit to surgery. Many feel that the amputee is usually psychologically crushed by his misfortune—doomed to a life of unhappiness. In our experience this is far from true. In fact the transformation of the toxic, pain-racked, bedridden, despairing pa-

tient before operation to the restful, painless, active, happy and hopeful amputee is one of the most gratifying experiences in surgery. Properly approached, nearly all patients will accept amputation when it is indicated, not one of ours persisted in refusing to submit, but one delayed about 3 weeks during which an unconquerable septicemia supervened.

#### INCOMPETENT CIRCULATION WITH INFECTION

The patient who has moderate cellulitis associated with ulceration or gangrene in an extremity with incompetent circulation may be treated conservatively for 24 hours or longer if improvement continues. He must be closely watched, however, for spread of infection, with frequent body temperature readings. When the patient's oral temperature rises to 101 degrees F. or higher, there exists so great a danger to the patient's life that we consider amputation mandatory, not as a hasty procedure but as an emergency, as great or greater than an acute appendicitis. One of our amputations was done at 12 00 p.m. because of a sudden temperature rise to a dangerous level.

#### ANALYSIS OF CASES

*Incidence.* As one would expect, the conditions requiring thigh amputation are more prevalent in the age groups in which degeneration of arteries is more common. Thus we find 27 of 36 amputations in those over 60, 16 were in the 6th decade. Yet even the 4th decade is not exempt from the same process, only 1 of the 4 amputations was due to thromboangitis obliterans. All 5 deaths in this series occurred in the patients over 60 (see Table III). Males predominate  $2\frac{1}{2}$  to 1 and the right side was amputated somewhat more often than the left.

*Presenting symptoms.* Outspoken ulceration or gangrene was the presenting symptom in 24 cases, pain and coldness in 6, and claudication in 4. The authors feel that a more painstaking history would have elicited previous complaints of coldness, numbness or claudication in a greater number.

*Reason for amputation.* Chronic ulceration or gangrene was reason for 34 amputations, 19 of these had spreading cellulitis. Two



amputations were performed for chronically infected below the-knee stumps. In all cases the extremity was the site of well developed occlusive arterial disease.

*Diabetic status.* Twenty amputations were done on patients with diabetes. In 10 the diabetes was mild in 3 severe. In 5 the presence of diabetes was discovered only on admission. The previous diabetic control in 13 cases was good or fair in 2 it was poor.

There appears to be no important correlation between the grades of severity, duration or previous diabetic control and the course after operation. The diabetics have been kept under strict postoperative control by the medical attendant. Thus a severe diabetic of long standing, if properly controlled seems to heal as promptly and with as few complications as the more recent and milder cases (see Table II) (The duration of hospitalization and days in bed are shown under a subsequent section.)

*Peripheral pulses.* It is remarkable that a dorsalis pedis pulse was felt in only one extremity and this pulse only barely palpable. The posterior tibial was absent in all but 2 in 1 it was of normal force in another barely palpable. The popliteal pulse was not felt in 24 cases the femoral in one. We have always placed considerable significance on the character of the dorsalis pedis pulses in determining the presence of peripheral arterial disease. In many hundreds of examinations of the lower extremities for vascular disease we recall no normal case in which the dorsalis pedis pulse was absent or markedly diminished. This was further brought out by Pearl and Kandel (13) who in an estimation of the peripheral vascular status in 100 unselected diabetics, failed to find the dorsalis pedis pulse absent in feet with normal circulation. The converse however is not true. The dorsalis pedis pulse may be felt in extremities suffering from advanced degenerative arterial disease with some claudication and total absence of the normal vasoconstrictor influence. The posterior tibial pulse is at times impossible to feel in apparently normal extremities.

Absence of the popliteal pulse in 24 cases is noteworthy. Many of these arteries at operation were sectioned without appreciable

bleeding. Despite this, most of the flaps healed *per primam*. This fits well the fact that the skin and subcutaneous tissues of the thigh and upper leg do not receive their blood supply from the femoral artery but from the profunda femoris and the anastomoses around the knee joint.

*Extremity pulse status.* All pulses below the femoral were absent in 21 cases every one below the popliteal in 10. In 1 case the pulses were normal in another none were felt. The presence of all pulses is not a guarantee that gangrene and infection will not occur or that amputation will not be necessary nor is the complete absence of all pulses including the femoral a hopeless situation. One patient in the first category died of toe amputation followed by thigh amputation one in the last enjoyed *per primam* healing.

*Postural color changes.* A definite degree of ischemia on elevation and rubor on dependency was present in every case. The author considers postural color changes as one of the most valuable tests in the determination of arterial insufficiency.

*Calcification of arteries by x-ray.* X-ray pictures were taken in 27 cases. The arteries cast shadows on the roentgenogram in 16 no shadows were noted in 11. The visualization by x-ray of calcification in peripheral arteries is unquestionable evidence of the presence of degenerative arterial disease but failure to find calcified arteries is no basis for the denial of the process. Arteries may be completely occluded by a soft degenerative process which casts no shadow on the x-ray film. On the other hand the degree of calcification by x-ray is no criterion of the ability of the vessel's lumen to transmit blood. Markedly calcified shadows are often thrown by vessels which at operation are found to carry a goodly stream. Obviously then calcium shadows cannot be used as a means of differentiation between thromboangitis obliterans and degenerative arterial disease.

*Preoperative days in hospital.* In 20 cases, operation was performed 5 days or less after admission of patient. This is the result of a crystallization of our ideas as to what one might expect of conservative treatment and in the stabilization of our indications for ampu-



TABLE II—WOUND HEALING—  
36 CASES

	Cases	Total
Per <i>primam</i> , total		
Diabetic only		
Nondiabetic only		
Delayed, total		
Extensive necrosis of stump	6	14
Hematomas without infection		
Small necrosis at suture line	3	
Mild inflammation of subcutaneous tissues		
Persistent abscess		
Slight persistent drainage		
*Stump acquiesces (4)		

a further modification in technique to be reported later has decreased the serous drainage.

The number of delayed healings is far too high, and every effort is being made to decrease it. It may not compare favorably with the number healing *per primam* when other amputation methods are employed. Yet the most important single goal in amputation for peripheral vascular states is to save life. Our results realize this goal not as completely as one would desire but very satisfactorily in comparison with mortality percentages in many other reported series. The long mobile end bearing stump and the absence of shock are features which no other method of amputation so well provides. Secondary operation on the stump is almost never necessary, whereas in guillotine amputations it is common. Many of those listed as "delayed healing" had comparatively minor complications which did not increase the period of preparation for or the ability to wear a prosthesis. All points considered we are of the opinion that our method of amputation is far superior to the older methods.

Of the 24 patients who had no palpable pulses below the femoral vessels 16 healed *per primam*. In this group there was no noteworthy difference in wound healing between diabetic and nondiabetic. The cases of delayed healing were not more severe in one group than in the other.

When one looks at the causes of death (Table III) he notes that 3 patients died of complications not associated with the condition for which amputation was performed. It is difficult to see how these could have been avoided. One should take into consideration

TABLE III.—ANALYSIS OF 5 DEATHS  
36 AMPUTATIONS

Case No.	Age	Diabetes	Preoperative blood culture	Cause of death	Remarks	
30	61	+	No growth	Infection and low count. Extensive stump necrosis	Refused thigh amputation for 4 weeks. Allowed for amputation only.	
6	39	6	+	Positive for hemolytic streptococcus	Septicemia. Excessive infection and necrosis of stump	Blood culture positive before operation.
10	30	4	+	No growth	Postoperative low infection and bronchopneumonia	Chronic coronary artery disease
13	58	72	+	Not done	Streptococcus meningitis, postoperative	Chronic arterial and venous sclerosis, chronic coronary artery disease
36	66	+	Not done	Pneumonia and cerebral thrombosis	Extensive and persistent after operation. Stump healing per primam.	

their ages which ranged from 64 to 72 years and that 2 had previously suffered from coronary artery disease. A certain minimum number of deaths must be expected in patients of this age group in which degenerative changes in vital organs are usually widespread.

Two patients lost their lives as the end result of the condition for which amputation was performed. One patient might well have survived if our plea for permission for thigh amputation had been heeded at once. We would be inclined in the future to refuse local amputation of an affected digit when in our judgment the indications for the necessity of thigh amputation have been definitely established. The other patient was subjected to amputation a few hours after blood was taken for culture. Forty-eight hours later the culture was reported positive for *Streptococcus hemolyticus*.

The total operative mortality of 5 cases in 36 (13 per cent) is a great improvement on

\*Percentage figures are purposely omitted to avoid the error which must appear in small series.

the mortality reported by most authors and compares very favorably with the best statistics. The 3 deaths resulting from the general state and not associated with the condition for which amputation was performed probably represent the effect of degeneration in vital organs due to age or diabetes or both, the authors cannot suggest how this proportion can be reduced. Certainly, there is an irreducible operative mortality due to this cause. Of the remaining 2 deaths both could probably have been prevented if the patients had sought competent surgical advice earlier and if they had accepted the advice when and as given.

#### SUMMARY

1 The authors present their experiences with atraumatic amputation of the thigh in diseases of the peripheral arteries.

2 The indications for thigh amputation depend upon the circulatory balance of the extremity. Local surgery for foot lesions is contraindicated when the arterial circulation is incompetent. The authors outline their views of surgical treatment of ulceration and gangrene of the foot, with and without infection in relation to the circulatory status.

3 The reasons are given for the choice of thigh amputation which transects no muscles.

4 A statistical analysis of 36 amputations performed by the new technique is presented.

5 Wound healing was delayed more often than we would desire. The other advantages of the operation outweigh this disadvantage.

6 There were 5 deaths in 36 amputations. Two of these could have been avoided by earlier treatment. Three patients with marked degenerative changes died of pulmonary and cardiovascular complications. These 3 probably represent an irreducible mortality.

7 Lumbar ganglionectomy performed in the stage of satisfactory vasoconstriction is the most efficient means of increasing the peripheral circulation and in preventing amputation.

#### REFERENCES

- 1 CALLANDER, C L. *J Am M Ass.*, 1935, 105 1746
- 2 *Ibid.*, 1938, 110 113
- 3 FAXON, H H. *J Am M Ass.*, 1939, 113 1199
- 4 KESSLER, H H. *Am J Surg.*, 1939, 43 560
- 5 McKITTRICK, L S. *Ann Surg.*, 1935, 102 342
- 6 *Idem*. *Am J Surg.*, 1939, 44 46
- 7 *Idem*. *Surg Gyn Obst.*, 1939, 68 508
- 8 *Idem*. *Arch Surg.*, 1940, 40 352
- 9 McWHORTER, G L. *Am J Surg.*, 1939, 45 316
- 10 PEARL, F L. *Am J Surg.*, 1939, 43 106
- 11 *Idem*. *Surg Gyn Obst.*, 1937, 65 107
- 12 *Ibid.*, 1941, 73 381
- 13 PEARL, F L., and KANDEL, A. *Arch Surg.*, 1939, 39 86
- 14 PRATT, G H. *Am J Surg.*, 1939, 43 573
- 15 SAMUELS, S S. *Surgery*, 1937, 2 225
- 16 *Idem*. *Surg Gyn Obst.*, 1939, 69 342
- 17 SILBERT, S S. *Clin N America*, 1938, 18 389
- 18 SMITH, B C. *Arch Surg.*, 1933, 27 267
- 19 *Idem*. *S Clin N America*, 1938, 18 337
- 20 TAYLOR, F W. *Surg Gyn Obst.*, 1938, 67 114.
- 21 *Idem*. *J Am M Ass.*, 1937, 113 1106
- 22 VEAL, J R. *J Am M Ass.*, 1938, 110 785
- 23 WHITE, W C. *J Am M Ass.*, 1938, 110 261

# FRACTURES OF THE ZYGOMA

## A Report of 72 Consecutive Cases

WALTER A. COAKLEY, M.D., F.A.C.S., and MALVIN F. WHITE, M.D., Brooklyn, New York

**A**LTHOUGH considerable has been written in medical literature in recent years concerning fractures of the jaws and nose, together with other facial injuries there has been a noticeable lack of literature based on a comprehensive study of fractures of the zygoma and its component parts. This relative silence is certainly not the result of an infrequency of occurrence of this type of injury as this paper will tend to show nor is it due to any difficulty either in diagnosis or treatment by those trained in the proper handling of this condition. Undoubtedly many such injuries are frequently "missed" merely because of lack of familiarity with the injury on the part of the examining clinician and do not become manifest to patients until some time after their occurrence.

Until fairly recently and in fact even now to some extent, traumatic injuries of the face especially those involving the bony framework, occupy a no-man's land in the field of surgery. The otorhinolaryngologist adequately cares for the acute fractures of the nasal bones, and the oral surgeon similarly serves quite capably in the care of acute fractures of the mandible and maxillae.

The exact field to which fractures of the zygoma belong is not so clear-cut or generally accepted. The writers have seen these cases cared for by both of the groups of specialists mentioned, and, in addition, by orthopedic and general surgeons, ophthalmologists, and of course plastic surgeons—especially those caring for maxillofacial injuries.

It is not within the realm of this paper to judge which group should control this field—nor would the writers so care to judge their colleagues, even if such were possible. Certainly however these fractures should be

treated only by those properly qualified to offer the patient the best possible end-result.

Obviously many men in various specialty groups have familiarized themselves sufficiently with the problems at hand, and, through their experience and understanding, are well qualified to render excellent treatment. The writers do however wish to call attention to the far too common practice of many who through lack of appreciation of the problem together with unfamiliarity with the methods of diagnosis and the treatment, have inadvertently and unwittingly often misguided the patient with the inevitable result of a marked deformity due to an obvious asymmetry of facial contour.

This is especially deplorable because the correction of the acute injury is, in most instances, a relatively simple procedure wherein the late correction of these deformities, once healing has occurred, is often quite a formidable procedure and occasionally the results thus gained hardly justify any operative interference. Thus the patient often must go through life with a marked facial deformity which causes the individual more anguish and torture than could possibly be caused by many diseases far more menacing to life.

In addition, unreduced fractures of the zygoma may result in visual disturbances, paranasal sinus disease, and interference with proper occlusion of the teeth. The latter may result in disease and poor functioning of the masticatory structures.

While injuries of the nature under discussion form a problem which cannot be over emphasized even in civilian practice its occurrence and importance as result of modern warfare tactics will be increased manifold. This should be true not only of the actual overseas combat units, but also will become apparent in training centers especially where mechanized divisions are on maneuvers.



Fig 1 Fracture zygomatic arch Before reduction by temporal approach



Fig 2 Fracture zygomatic arch After reduction by temporal approach

This paper represents a comprehensive study of 72 consecutive cases of fracture of the zygoma admitted to Kings County Hospital during the 3 year period from July, 1939, to June, 1942

*Admission to service* Although all cases of the nature under consideration are treated by the Plastic and Oral Surgical Service in Kings County Hospital, only 21, or 29 per cent, of the entire group were initially admitted to this service

By far the largest group, 48, or 66 $\frac{2}{3}$  per cent, were admitted to the Neurosurgical Service. This is readily understandable since so many of these patients suffered from head injuries or gave histories which made neurological observation for at least an initial period advisable. This is an important observation, for unless the neurosurgeon is familiar with the signs and symptoms, as well as the importance to the patient of early treatment of zygoma fracture, many of these cases will not be diagnosed until the resulting deformity becomes obvious to all concerned—and then, often, so much time has elapsed that the early, simple methods of reduction are ineffectual. Undoubtedly, considerable credit for “finding” many of these cases is due the house staff of the Neurosurgical Service whose keen interest in the problem and thorough examination of the patient resulted in the relatively high incidence of diagnosis of fractured zygoma.

*Cause* Lothrop (1916) and Gillies and his associates (1926) called attention to the fact

that zygoma fractures were always due to direct violence, and this has been substantiated by other reports. The findings in this series are entirely in agreement with these previous reports concerning etiology. This study indicated that the most important single cause was vehicle accidents—automobile and trolley, respectively—which constituted 31 cases, or 43 per cent, of the entire group. The next most important causes, in their respective order, were first blows, 16 cases, falls, 8 cases, which were further divided into 4 cases in which patients fell as result of alcohol intoxication, 2 as result of epileptic convulsions, 1 slipped on an iced street, and another “missed” a step and fell headlong down the stairway, 5 patients were struck by foreign objects including baseball, 2 cases, baseball bat, 1 case, dishpan, 1 case, and lead pipe, 1 case. In 12 cases the cause was not determined for the patients were so intoxicated that no history was obtainable on admission to the hospital and even after recovery from this alcoholic somnolence, they either did not remember or gave such contradictory statements that no credence could be attached to their stories. For that reason it was thought best not to include them in this analysis from an etiological standpoint.

Thus, in the entire 72 cases, 43 per cent resulted from automobile and trolley accidents, 22 per cent from fist fights, 11 per cent were due to falls, 7 per cent due to blows by foreign objects, and 17 per cent were not de-



Fig. 3. Fracture of body before reduction. Arch intact. Infraorbital ridge depression.



Fig. 4. Fractures of body reduced. Intraoral approach.

terminated. Naturally if the latter group was not included, the percentage of each of the groups of known causes would be considerably higher.

**Age.** While obviously no age group would be immune to fractures, the youngest patient in this series was 14 years of age and the oldest 63. However, 60 per cent of all the cases occurred in the age group ranging from 20 to 38 years. The average age of the entire group was 35.4 years.

**Sex.** Straith analyzed a group of automobile accident cases and found a marked preponderance of facial injuries occurring to the "driver's guest"—the person seated on the right side of the front seat. Most of these casualties were females. This latter finding is not in agreement with the statistical study of the 73 cases presented herein which revealed that only 15 females suffered from fracture of the zygoma as compared with 57 males. This ratio of males to females affected is almost 4:1. Even considering only the 3 cases of 43 per cent, resulting from automobile accidents and omitting the remainder due to other causes, there was still a marked preponderance of injuries in the male sex.

**Side of injury.** In 5 cases bilateral zygomatic fractures existed. In the remaining 67 cases, 52 occurred on the left side and only 5 on the right; ratio of left to right almost 3:5.

**Number of fractures.** Zygomatic fractures are usually multiple. In only 4 cases did a single fracture exist. Two fractures occurred

in 28 cases, 3 fractures in 22 cases, 4 fractures in 10 cases, 5 fractures in 7 cases, and 6 fractures occurred in 1 case.

In 70 per cent of all cases patients had either 2 or 3 fractures. The average of all the cases was 3 fractures and the total number of all 73 cases was 207 fractures.

**Site of fracture.** The most frequent sites of the fracture together with the incidence of their occurrence are as follows: arch, 119 times; infraorbital, 44 times; frontal, 23 times; maxillary, 21 times.

Just as more than one fracture usually occurred in each case, so did a combination of 2 or more fracture sites occur in a single case. This was especially so with depressed fractures of the body of the zygoma.

**Signs and symptoms.** The most frequent signs and symptoms and their incidence of occurrence were as follows: (1) periorbital swelling and ecchymosis, 67 cases; (2) local tenderness on palpation, 67 cases; (3) palpable depression or irregularity of contour, 61 cases; (4) pain—constant, 59 cases; (5) pain on mastication, 49 cases; (6) asymmetry between left and right sides on finger palpation intraorally between ramus of mandible and the maxilla, 46 cases; (7) epistaxis, 45 cases—39 of these 45 were associated with depressed fractures of the body of the zygoma injuring the antral mucous membrane. Only 2 such fractures failed to produce epistaxis. On the other hand only 6 of 31 cases of arch fractures experienced epistaxis.

tion of infraorbital nerve ranging from paraesthesia to anesthesia, 35 cases, all of which were associated with depressed fractures of the body, none with fractures of the arch alone, (9) conjunctival hemorrhage, 34 cases, (10) visual disturbances, diplopia, 18, blurred vision, 7—25 cases, (11) visible depression, 23 cases, (12) headache, 16 cases, (13) drooping of face and lip, 14 cases, (14) difficulty in opening mouth, 12 cases, (15) dizziness, 11 cases, (16) anesthesia over distribution of infraorbital nerve, 4 cases, (17) mobility or crepitus, 3 cases, (18) subcutaneous emphysema, 2 cases

*Associated injuries* Due to the location of the zygoma and its component parts, the nature of the accident, and the force necessary to cause its fracture, it is to be expected that other injuries often might occur associated with these fractures. Practically all of the patients showed evidence of local contusion. Nineteen, or 26 per cent, suffered from cerebral concussion, 16, or 22 per cent, had lacerations of the cheek or face (very few of these communicated with the fracture site, however), 10, or 14 per cent, had fractured mandibles including 3 cases of fracture of the coronoid process which is one of the rarest fractures of the mandible, 9, or 12.5 per cent, had fractured nasal bones, and there were 8, or 11 per cent with fractured maxillae.

*Time of operation* Admission to hospital ranged from a few minutes to 12 days following injury. The average was 32 hours. This meant that even without any serious associated injuries some of the patients were not operated upon immediately due to the amount of swelling present. In addition, as previously stated, in only 29 per cent of these cases were patients initially admitted to the plastic service. Therefore, there was even more delay in time consumed by consultations between the services, x-ray studies, and the like.

However, in spite of this, all patients requiring operation were operated upon from 2 hours to 2 weeks following the injury. Eighty-five per cent of all operations were performed in the period from 2 to 6 days following injury. The average time after injury for all cases was 4.1 days.

*Reduction of fracture* In general, fractures of the zygoma should be reduced immediately,

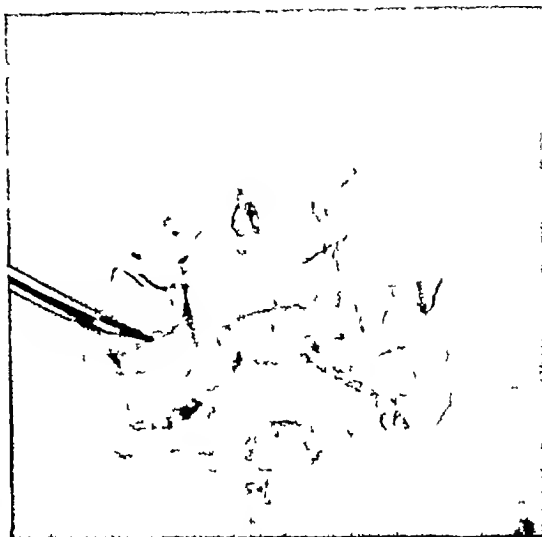


Fig 5 Diagram of intraoral approach

before swelling begins, or, if that is impossible, it is better to wait 5 or 6 days until the swelling subsides. Ice compresses or other similar local aid in prevention of swelling may be used.

Obviously, there are many approaches to any operative procedure and it is not the purpose of this paper to attempt to convert one from his tried and proved method of reducing fractures of the zygoma and its component parts to the methods which have proved the most satisfactory to the writers. In any given case certain advantages and disadvantages are readily recognized with all of the methods of approach, and the final decision must be determined by the nature of the injury and the personal experience of the operator.

We favor two methods of approach, for these have afforded the best results in our hands. Each has its place, and either one or the other method usually is best suited for the particular injury at hand and is used, therefore. Occasionally a combination of injuries may necessitate the use of both methods in the same case to effect the best results.

The temporal approach, first described by Gillies and associates was used to elevate into position the depressed fractures involving only the arch, or even the body in cases in which the fractured fragment had sufficient posterior projection to enable an instrument to be en-



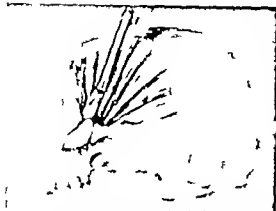


Fig. 6 Diagram of temporal approach. Fracture of arch.



Fig. 7 Replacement of arch. Temporal approach.

gaged behind it and provided the wall of the maxillary sinus had not been too badly comminuted and depressed into the antrum. This method based upon an anatomical study of the superficial temporal fascia and its relation to the zygomatic bone and its component parts, has the advantage of being performed through a sterile operative field which no oral or nasal method can claim. Also with the incision being placed above the hairline no visible scar results. It is a simple procedure easily and quickly performed and the chances of complications are minimal. While this was considered the method of choice wherever feasible it has its limitations.

In those cases in which the force of the blow caused the body of the zygoma to be driven downward and into the antrum with lowering of the infraorbital ridge and multiple depressed fragments of the wall of the maxillary sinus itself—the temporal approach proved ineffective.

A counter force directed from within the antrum to elevate and re-deposit the depressed fragments into their original position, and at the same time to drain the antrum was deemed the method of treatment. In this series of cases the antral approach was performed exclusively through the vestibule of the mouth as for a Caldwell Luc operation rather than through the nose as used by Shea, Watkins and others.

In all instances in which the antral method was employed, a careful search following inci-

sion of the mucoperiosteum over the sinus wall revealed an opening into the antrum at the fracture site sufficiently large to permit a medium size curved urethral sound or any similar blunt instrument to pass within the sinus without further enlarging the opening.

**Complications.** The only untoward complications encountered in all the operations was hemorrhage. This occurred in 2 cases during the operative procedure. In both instances the fracture was relatively old (12 days and 14 days respectively). The instrumental breaking up of the early healing fractures resulted in injury to branches of the internal maxillary vessels. In both cases packing was employed to arrest the hemorrhage and in one of these cases, the hemorrhage recurred 3 days after operation necessitating the repacking of the wound. Neither patient suffered from shock and both made excellent recoveries.

**Operative cases.** Of the 72 cases 42 were operated upon to reduce fracture, 30 were not. Of the latter nonoperative group, 2 signed their release from the hospital against the advice of the attending surgeon. This group included mainly alcoholics on the neurosurgical service. Two of these returned 6 months to a year later and now will require more complicated and less desirable procedures to correct their deformities.

Among the 42 who had reductions, the selected operative approach in 23 cases was through a temporal incision in 4 cases the antral approach through the vestibule of the

mouth was used, 2 patients required a combination of temporal and antral elevation, and 2 patients were reduced through the oral approach posterior to the antrum without opening the latter.

Of the 14 antral approaches 8 required packing of the sinus to maintain the elevation of the fractured fragments. This original packing remained in place 8 to 14 days and was then removed and the antrum was not repacked.

All of these patients were closely followed by postoperative check-up examinations. The shortest "follow-up" period of observation was 5 months and the longest 15 months, average of the 8 cases being 9 months. These periodical examinations included history, physical examinations, and sinus x-rays. In no instance were there any signs or symptoms of sinusitis, nor was there any x-ray evidence of any infection.

*Postoperative course.* The number of days spent by the patients in the hospital following the date of operation varied greatly depending primarily upon the nature of the associated injuries rather than upon the local injury under discussion. However, even the latter influenced this postoperative convalescence to a definite degree. One patient, who suffered multiple and bilateral fractures of the pelvis, tibia, femur, os calcis, and mandible was in the hospital 13 months. On the other hand, patients having no serious injuries other than fracture of the zygoma were discharged in from 1 to 14 days later.

The operative procedure employed, which was determined by the site and nature of the fracture, definitely modified the postoperative course. Those patients requiring reduction of the fracture through the antral approach, draining, and packing of the maxillary sinus remained in the hospital longer, ran a slightly higher temperature, and for a somewhat longer period in general than did those in whom the temporal approach was used (Table I).

One explanation for the discrepancy in so far as the period of hospitalization is concerned is that it is quite possible that we may have erred on the side of conservatism in not permitting the patient to be discharged until the packing placed into the antrum had been

TABLE I — POSTOPERATIVE COURSE

	Temporal	Antral
Postoperative days of hospitalization	1-6	4-14
Average days	3	7
Highest postoperative temperature recorded—degrees	100.2	100.8
Longest postoperative temperature elevation—days	3	5
Average postoperative temperature elevation—hours	24-36	48-72

removed. Thus hospitalization was prolonged, but the end-results seem to have justified this practice.

There was not one single case of postoperative infection in the entire series.

*External approaches besides temporal.* The external approaches besides the temporal include (1) elevation of depressed bone by use of a tenaculum, a cow-horn dental forceps, or a towel clamp through the skin to grasp the bone (Gill), (2) the Collins slip-lock (Patterson), (3) the Hagedorn needle, thread and copper wire (Matas), (4) a corkscrew-shaped instrument passed into the bone and traction then used (Roberts), (5) a hook passed beneath fragment through small nick in the skin (New).

*Intraoral methods.* The intraoral methods include (1) a small incision in mucobuccal fold above the second molar. An elevator introduced and carried beneath malar bone, and is elevated with the maxilla as fulcrum (Goldthwaite, Straith), (2) the antrals as practiced by Lothrop, Blair, Ivy, Naftzger.

*Nasal approach.* The nasal approach is accomplished by means of (1) a Ritter sound through the intranasal antrotomy (Shea, Watkins), or a clot is displaced by means of vaseline gauze and the gauze is then withdrawn.

*Immobilization.* Immobilization is accomplished (1) with a drill hole wire or head cap (Kazanian), (2) with a conical thread screw (Akerman) or (3) by direct wiring.

#### SUMMARY

1. This report includes 72 cases of fracture of the zygoma treated by the authors. In 85 per cent the result was excellent and in all of these cases operation was performed within 2 to 6 days after injury. In the 15 per cent remaining there was considerable improvement, in these the operation was done late

2 Two methods of operative approach have proved most useful in reducing these fractures the temporal and the Intraoral.

3 Packing the antrum and allowing the packing to remain 8 to 14 days apparently caused no harm.

4. Reduction should be attempted no later than the 6th to 10th day whenever possible

5 Early operative reduction is a relatively simple procedure Late operative reduction is more formidable

6 Postoperative infection was extremely rare.

7 Early diagnosis contributes greatly to successful reduction

## REFERENCES

- AXERD N. Acta chir scand 937-938, 46  
359.
2. BLAIR, V. P. and IVY, R. H. Essentials of Oral Surgery St. Louis C. V. Mosby Co 1936.
  3. GILL, W. D. South. M. J. 93 7 97
  4. GELLNER, H. D. KILNER, T. P. and STONE, D. Brit J Surg 937 4 65
  5. GOLDENSWAITE, R. H. J. Am. M. Ass 924 8 628.
  6. KATZ, H. V. H. J. Am Dent Ass 927 4 60-
  7. LOTNICKOFF, H. A. Boston M. & S. J. 906, 54 8
  8. M. AD, R. N. Orleans M. & S. J. 906, 49 30
  9. NARTINGER, J. B. Ann. Otol. Rhinol., 934, 37 494
  - NEW G. B. Surg Clin N. America 935 5 24
  - P. TIKHONOV, R. F. J. Bone Surg 935, 7 orig
  2. ROBERTS, S. E. Ann. Otol. Rhinol 928, 37 825
  3. SHERA, J. J. J. Am. M. Ass 93 96 4 8
  4. STRAUSS, C. L. J. Am. M. Ass 937 98 91
  5. WATKINS, A. B. K. Brit. M. J. 937 3 7

# THE SULFANILAMIDE OINTMENT TREATMENT OF SEVERE BURNS

IVIRITT IDRIS IVANS, M D, Ph D, and M J HOOVER, M D, Richmond, Virginia

FOUR general problems confront the surgeon treating a patient with a severe widespread burn (1) shock produced by local plasma loss, (2) 'toxemia,' (3) the prevention of infection, and (4) early grafting of the burn surface should this prove necessary. Concerning the prevention or treatment of shock there is now general agreement that administration of plasma is exceedingly beneficial. Of "toxemia," we know little as to causes or treatment, except that recent evidence indicates that tannic acid is definitely a hepatotoxic agent. Of the third problem, infection it is believed that the most fruitful method of solution has been meticulous care in "the conversion of the open contaminated wound into a clean wound" by proper cleansing, excision, and dressing.

It should be kept in mind by all who must treat a burn that no matter what the physical or chemical characteristics of the ointment or spray to be employed, the agent applied to the burn surface should possess certain qualities: (1) It should not produce toxic effects, local or systemic, immediate or delayed, (2) if possible it should be somewhat bacteriostatic, (3) it should permit early mobility of joints and flexor surfaces, if this is desired, (4) it should not injure remaining viable epithelial elements that would produce early epithelization, (5) it should inhibit plasma loss (in second degree burns), (6) the method of application should possess a certain flexibility and simplicity, without sacrifice of fundamental principle, to allow for the treatment of mass burn casualties, either civilian or military.

In this paper we wish to outline a method for the local treatment of severe burns which possesses most of these qualities and which employs nothing more in the local therapy

than the application of a simply prepared and simply applied oil-base sulfanilamide ointment. The method can be easily adapted to mass casualty use, either civilian or military. This paper will deal only with the immediate primary treatment of the burn surface. What we have learned relative to the subsequent care of severe burns will be discussed in a separate communication.

All burned patients considered in this paper were severely burned and were hospitalized. In general, the average burns covered about 15 to 20 per cent of the body surface, many in the neighborhood of 40 per cent and 1 approximately 75 per cent (Fig 1, a). A large percentage (39%) of the burned patients were children. The depth of the burns can be judged rather easily in that 36 per cent required grafting. One hundred and twenty-six patients were treated by the method to be outlined, in this group there are 3 deaths.

Sulfonamide ointments have been reported by others to be useful in burn therapy. Allen, Owens, Evans and Dragstedt (2) treated 2 patients with severe burns with recovery, and Gurd, Ackman, Gerrie and Pritchard have treated 31 "major burns" with a sulfathiazole emulsion with excellent results. There has been a considerable and sometimes not entirely understandable hesitancy on the part of many surgeons to use sulfanilamide locally in wounds. In Dr I A Bigger's clinic<sup>1</sup> in this institution sulfanilamide has been used locally in several thousand potentially infected wounds since 1938. All of us here are now absolutely convinced of the wisdom of this treatment, in its local use in burns we have simply applied the lessons learned in other types of wounds.

## SULFANILAMIDE OINTMENTS

The sulfanilamide ointment used in these burns is of simple composition, is inexpensive,

<sup>1</sup>Dr Bigger, chief of surgery arranged facilities which made this work possible and gave freely of both his time and most appreciated critical judgment.

From the Department of Surgery, Medical College of Virginia, Richmond, Virginia.

Some of the work described in this paper was done under a contract recommended by the Committee on Medical Research between the Office of Scientific Research and Development and the Medical College of Virginia.

and is easy to prepare. We wish to state emphatically that what we have to say regarding the use of sulfonamide ointments in burns applies only to one type of ointment, namely that which employs a fatty base. We shall report elsewhere our studies on a series of burn patients in which a comparison was made of relative absorption of sulfonamides from a fatty or water-dispersible base. It is necessary to report here only that dangerously high blood levels of sulfonamides were obtained when the water-dispersible base was employed in burn therapy.

The sulfanilamide ointment used is made from equal parts of sterile lanolin and cold cream to which is added by thorough dispersion sterile sulfanilamide powder to a 6 per cent concentration by weight. Absorption of sulfanilamide from this fatty base must be very limited and slow blood levels being in the neighborhood of 1 to 2 milligrams per cent for days after the ointment has been applied to the burned surface.

Sulfanilamide rather than sulfathiazole or sulfadiazine has been used because it has been our experience that we see less severe unfavorable reactions with sulfanilamide than with the other two sulfonamides. Further it has been so effective that we have not felt it necessary to use these other drugs.

#### PRINCIPLE OF SULFANILAMIDE OINTMENT THERAPY

No matter what treatment is used for the burn locally every attempt should be made to prevent or treat shock. Plasma lost in the initial hours after the burn has been received should be replaced to the extent that shock is prevented. It may be considered heresy but we have come to pay little attention to the application of mathematical formulae introduced by others to calculate plasma needs in an individual burn case. Our experience in this fairly large series of severe burns, supported by careful daily estimations of plasma volume by the dye technique of Gregersen indicates that it is very wasteful of plasma to attempt to restore plasma volume fully before the 40th to 70th hour after the burn has been received. In general we have attempted to give plasma in 250 to 500 cubic centimeter

amounts in the first 24 to 36 hours no matter what the extent of the burn except in those patients in whom shock was present or impending. Hematocrit determinations are made every 6 hours; an attempt is made to keep the hematocrit levels in the neighborhood of 50 to 55 during the first 7 days. This has demanded a more careful watching of many patients, but much plasma has been saved and only 4 instances of shock have been noted. (One in the 75 per cent burn he received large amounts of plasma.)

We have become enthusiastic advocates of the Koch Allen (1) principle of pressure dressings to the burned areas. These dressings have been applied in the great majority of burns treated in this series; this may account in large part for the low incidence of shock in the first 36 to 40 hours.

We are in such accord with the general principles of burn therapy outlined by Allen and Koch that it is unnecessary to go into detail of the background of the sulfanilamide ointment treatment of burns. Briefly every effort is made to convert the contaminated wound into a clean wound by proper excision of easily removed necrotic tissue and proper gentle cleansing of the burns with simple soap and water. Every person coming in contact with the burned patient is obliged to wear a mask, thus preventing mouth-borne infection (hemolytic streptococcus). Locally applied sulfanilamide slowly absorbed prevents infection; early repair of epithelium is possible only when infection is absent. Pressure dressings reduce plasma loss, and in conjunction with splinting afford proper rest for the injured part.<sup>1</sup> Primary dressings are left in place 7 to 9 days so that time is afforded for natural repair of the burned area.

#### TECHNIQUE

In the series of photographs (Fig. 22-27) we illustrate the details of the sulfanilamide ointment treatment of burns. All burn patients are cared for from inception of the burn to the end of the treatment including skin grafting by a burn and shock team. When the

<sup>1</sup> We have made exception to this rule in very severely burned patients. Here only a rapid, antiseptic, convulsant and paralytic dose (veronal) has plasma being given to the patient during the improving shock period.

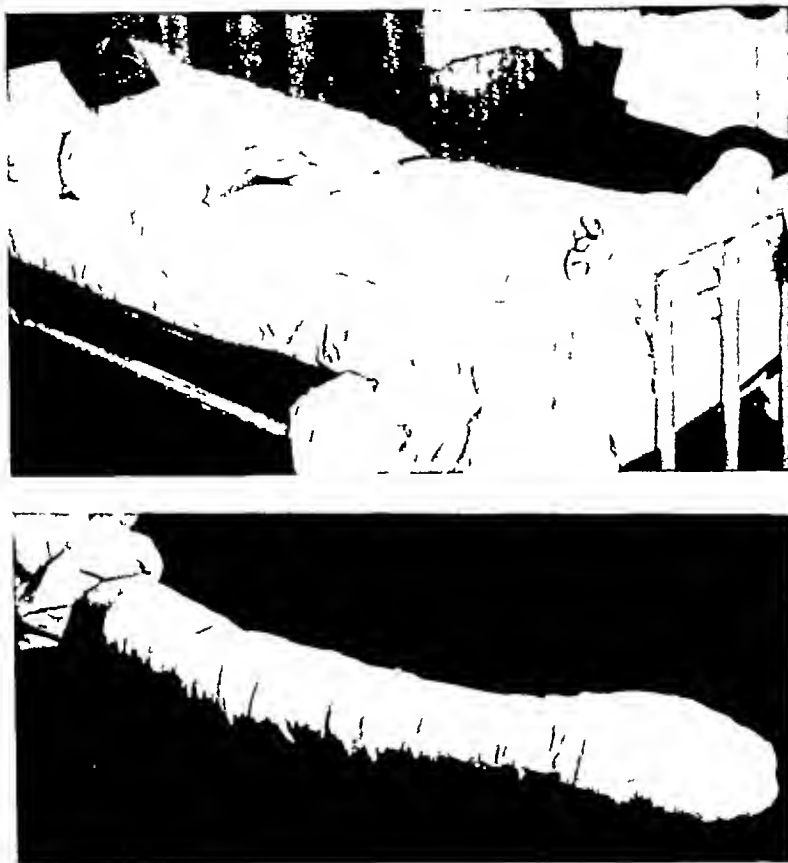


Fig 1 a, above, Patient with dressings applied to almost entire surface of body b, Appearance of arm in pressure dressing

patient is admitted to the emergency room (Fig 2a), he is given morphine immediately in adequate doses (adults grains  $\frac{1}{4}$ ) to allay pain. Recently we have been using sodium luminal with morphine. No other anesthetic is allowed. Attendants and patient are immediately masked to prevent mouth-borne infection. The patient is placed on a stretcher and covered with sterile sheets and towels.

The patient when quiet and free from pain is taken to the operating room (Fig 2b), where the burned areas are gently washed with copious quantities of white soap and sterile saline by members of the burn team who have prepared themselves as for any operation employing aseptic technique.

Once the burned areas are clean, excision of easily removed dead skin is begun (Fig 2c)

No obvious dead tissue is left, but an attempt is made not to injure healthy tissue. Figure 2d illustrates the extent of excision in one hand of this burned patient.

When the burned areas are thoroughly cleansed and débrided, a liberal quantity of the oil-base sulfanilamide ointment is applied to all burned areas (1st, 2d, and 3d degree) with a tongue blade (Fig 2e). Almost as soon as the burn surface is covered with sulfanilamide ointment the patient states he is relatively free of pain. The anesthetic property of sulfonamide ointments has been mentioned by Gurd and associates. It is not necessary to add any other local anesthetic agent to this ointment. Sterile surgical compresses are placed over the ointment (Fig 2f). Fingers are individualized. Next a pressure dressing



b



d



f

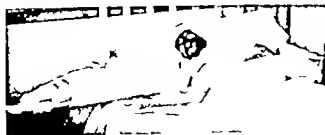


Fig. a. Patient is placed on sterile sheets and given adequate doses of morphine so that all pain is relieved. If the burn is widespread the initial dose is usually  $\frac{1}{4}$  grain morphine to the adult. All nurses and doctor attendant in the emergency room are masked. b. With no other anesthetic than morphine administered, all burned areas are washed gently with boric soap and sterile water under strictly aseptic conditions. If possible, this is done in operating room. c. Blbs are spread and the dead skin is removed by scissors or

(See opposite page)

is applied. We have used gauze rolls, surgical bandage, and Ace bandages but for general use have come to like the regular "leg" roll best of all of these for application of pressure. Care must be taken not to attempt too much pressure, lest nerve injury result.

After the pressure bandages are in place, the patient is put in a bed on sterile sheets and proper splinting of arms or legs carried out (fig. 2g). Both wooden and plaster splints have been used.

The same treatment is used for all parts of the body that may be injured by the burn; this includes the so-called critical areas: face, hands and genitalia. In the early part of this study, pressure dressings were applied to the face, we no longer do this, since the edema of the face seems to recede by the 4th day, whether or not pressure dressings are used, and the patients complain less when the face pressure dressing is not employed.

If a burn is seen late or is infected when first seen, the method here outlined is not used. Instead, warm continuous saline compresses are placed at once on the burned areas and these are used until the burned areas are surgically clean. If the infection is severe, sulfathiazole is given by mouth and sulfanilamide powder is used locally.

#### OBSERVATIONS WITH SULFANILAMIDE OINTMENT PRESSURE THERAPY IN SEVERE BURNS

**Shock.** As mentioned, shock has occurred in only 4 patients in this series. More cases of "shock" may have been present, and simply not observed. It may well be that the criteria used for shock (low blood pressure, rapid pulse, poor venous filling time, etc.) are inadequate in the study of shock in burns. Our

knife excision. Care is taken not to injure healthy normal tissue. In military surgery this step need not be employed if time and personnel are not available. d, This photograph illustrates the amount of dead skin that was removed in the burned hand of this particular patient. e, The fatty base sulfanilamide ointment is spread in a thick layer over all the burned surface. As soon as the ointment has been applied any residual pain is relieved. f, Sterile gauze compresses are placed over the sulfanilamide ointment. Fingers are individualized. g, After all the pressure dressings have been applied the patient is placed in a bed with sterile sheets. Arms and legs that have been burned are splinted for several days. This primary dressing is not removed for 7 to 9 days, depending upon the amount of 3d degree burn and subsequent discharge.

patients are usually seen quite early ( $\frac{1}{2}$  to 1 hour) after the burn is sustained, because of a well organized city ambulance service, so that pain is quickly relieved. Plasma is given early after admission. We are inclined to believe that the early application of the pressure dressing has diminished the incidence of shock.

**Toxemia.** We had treated earlier a number of burned patients by the tannic acid silver nitrate method. We have been surprised at how much less "toxemia" has been observed in patients treated by the sulfanilamide ointment method, than when tannic acid was used. There is no doubt that some of our severely burned patients have been "toxic" during the first 3 to 5 days following the burn, but the number has been small. We are aware that when large areas of 3d degree burn are sloughing the patient may appear toxic, the appetite may be poor, and the temperature elevated to 101 to 103 degrees F. If daily saline baths are started soon and the slough separates early, the "toxic" period is short. We are inclined to the view that patients may show some toxemia as long as the slough remains. This we believe is not due to the absorption of a specific burn toxin, but rather to absorption of split-protein products formed by the disintegrating, sloughing tissue.

In 15 severely burned patients, prothrombin times were estimated daily during the first 3 to 4 days following the burn. There has been no evidence of severe liver damage in this series, the prothrombin time of the burned patients closely approximating the controls (usually control 15 seconds, burn 18 seconds). Jaundice has not been observed in this series. Any nitrogen retention has been relieved, usually after about the 3d day.

The fact that no general anesthetic was given to any of these burn patients may account in part for the relative absence of toxemia.

A sulfanilamide "rash" appeared in 3 patients. This was relieved when the sulfanilamide ointment was removed and the sterile vaseline was applied. The relative absence of systemic reaction to sulfanilamide is due, we believe, to the very limited absorption of the drug from the burn surface when the fatty base is used.





Fig. 3. This photograph illustrates the results obtained in the use of sulfanilamide ointment in the treatment of widespread second degree burns in a 9 year old child. The outlined (burned) area was covered with large blebs which were removed at the initial dressing and sulfanilamide ointment was applied. The photograph was taken immediately after removal of the primary dressing on the 6th day. All of the burned area was practically healed and the patient was discharged on the 14th day.

Cyanosis has not been observed in any burn case when the fatty base was used but was a common complication in the studies in which the water-dispersible base was employed.

**Infection in burns.** Allen and Koch have presented this problem well when they state that "for years past infection has hung over the head of the burned patient like the sword of Damocles." To our minds there is no more important matter in the care of burns than the prevention of infection.

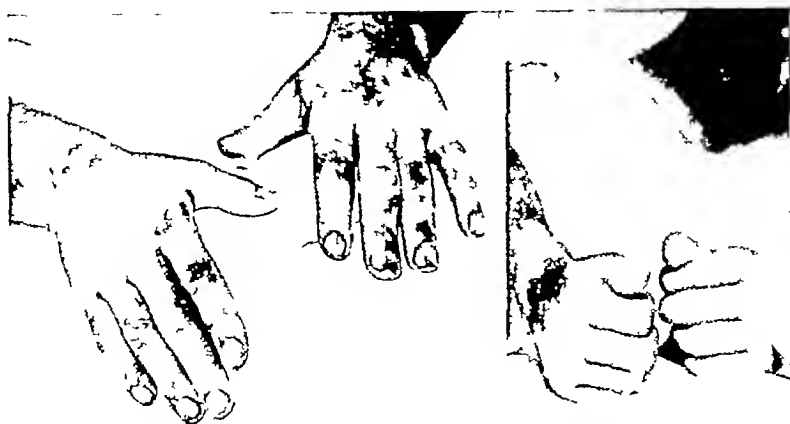
No quantity of a bacteriostatic drug such as sulfanilamide applied locally can prevent infection if overwhelming numbers of bacteria are implanted on the wound. This demands that great care be taken by all who come in contact with wounds (especially burns) care

fully to wash themselves and make certain that their hands and their surgical instruments are free from pathogenic bacteria. In second degree burns it may be well to remove with great care all superficial skin that is obviously dead but it is simply foolish to speak of "thorough deep excision of all dead tissue" in third degree burns as a primary step in the treatment of such severe burns. It is our belief that most burned patients will not tolerate this added trauma. Thus the intention of one treating a burn should be to prevent so far as is possible infection of the burned area by mouth and nose borne organisms (proper masking) and by ordinary pathogenic bacteria found on unclean hands and instruments (soap and water cleansing, gloved hands, sterile instruments)



Fig. 4. a, left, A deep burn of the arm and hand caused by gasoline explosion. This photograph illustrates the appearance of the burned area after removal of the primary dressing on the 7th day. Numerous islands of epithelium can be seen intact. Sulfanilamide ointment plus pressure again used in this patient. b, illustrates the appearance of

this arm after the removal of the second dressing on the 14th day when the burn area was practically healed. The patient was discharged on the 16th day with perfect use of the hand and arm. It was in this patient that there was persistent pleural loss despite considerable pressure used in each dressing.



Figs 5 a and b, Illustrate the degree of healing seen on the removal of the primary dressing in the hands of the patient illustrated in Figures 2, a to g, on about the 10th day after the burn had been received. It will be seen that there is rapid healing of the burned surface with normal flexion of the fingers.

There have been a few instances of infection in this burn series in which *Streptococcus pyocyanus* and *Staphylococcus albus* have been cultured. These occurred late in the therapy of 3d degree burns, and were easily controlled by simple measures. It is noteworthy that there has been no single instance of any type of infection in any severe superficial or deep 2d degree burn in this series, nor any single instance of infection by the hemolytic streptococcus in any burn in this series. Proper masking, strict surgical asepsis, and meticulous care are in no small part responsible for this result, but we are firm in our conviction that some credit should be given to the local application of sulfanilamide.

**Healing time of burns** The average superficial 2d degree burn is found to be healed when the first dressing is removed on the 7th to 9th day (Fig 3). The deep 2d degree burn requires further dressing but is usually well healed by the 14th to 18th day (Fig 4a-4b). The prompt healing of second degree burns has ceased to be a problem in this hospital since we began the use of this treatment.

The healing of 3d degree burns largely depends on the time it takes for the slough to separate, and healthy, clean granulation tissue to form, so that skin grafting may be begun. For small areas this may be as early as 14 days with the treatment outlined, but when large areas (30 to 40%) are involved we have

often been discouraged to note that 4 to 5 weeks have passed before skin grafting could be undertaken. So far as we can determine, the sulfanilamide ointment therapy (or simple vaseline) in no way delays or hastens the time when skin grafting may be done in a 3d degree burn. We do believe, however, that tannic acid therapy definitely brings a delay because of the slowness of the slough to separate, in some cases.

There have been those who state that locally implanted sulfanilamide delays the healing of a wound. Our experience (and that of Gurd and associates) with sulfonamide ointments in 2d degree burns causes us to believe that we could hardly expect more rapid healing of the burned area. Also, we have applied the test suggested by Cannon and Cope and find that when dermatome grafts are cut at 0.012 inch thickness, and our fatty base sulfanilamide ointment, boric acid ointment, and vaseline applied to certain areas of the donor site, all areas heal at the same rate. Here there is no indication that this type of sulfanilamide ointment delays wound healing.

**Local plasma loss** Many of the advocates of the tannic acid method for the treatment of 2d degree burns use that method because they feel that with no other method does one obtain such rapid cessation of local plasma loss. We are rather inclined to accept this point of view if one in considering "superficial" 2d



Figs. 6. a and b. This child was burned on the face, chest, hands and forearms by boiling water after a fall. a, Illustrates the appearance on admission to the emergency room; b, the

degree of healing 3 days after removal of the primary dressing (5th day). The granulating areas were grafted early and this patient was discharged on the 30th day after entry

degree burns which may "weep" badly, but we have been surprised to learn in this study that in only 1 case (Fig. 4a) were we troubled with persistent local plasma loss once the sulfanilamide ointment had been applied to the debrided burn surface. In all cases except the one mentioned, no further troublesome plasma loss occurred.

It may be that we have been dealing mainly with deep 2d and 3d degree burns. Certainly the accounts given us by naval medical personnel of local plasma loss in certain flash burns would cause us to suspect that no local burn therapy but tannic acid (or another escharotic method) would prevent serious plasma loss in this type of 2d degree burn.

Plasma loss in the 3d degree burn is another matter. In our experience there is practically no external loss of plasma in 3d degree burns; the loss there is the white hemorrhage of Allen and Koch plasma lost into the subcutaneous tissues under the burn. It is in the 3d degree burn that one sees the poorest results when tannic acid is used. To us it seems wholly illogical to cover the surface of a 3d degree burn with an heavy eschar to prevent plasma loss. The net result is no decrease in plasma loss, but one is left with a heavy eschar which acts almost as a barrier to the escape of products of the degenerating skin

beneath the eschar. "Surgical drainage" of the "wound" cannot take place. It is no wonder that such eschars almost "float" on the burn surface after a few days.

**The critical areas.** It is with severe burns of the hands and face that our results with the sulfanilamide ointment treatment of burns have been so gratifying. Given an opportunity for natural repair without having to overcome undue therapeutic hazards and obstructions, hand injuries do amazingly well (witness the published photographs of Kanavel, Mason, or Koch in extremely severe trauma to the hands). We believe that the greater proportion of hand burns will do equally well if treated with sulfanilamide ointment. With this treatment the 2d degree burned hand can be mobilized immediately after the removal of the primary dressing. Third degree burns of the hand can be grafted at quite an early date.

We have not hesitated to use the treatment outlined on trunk burns. From a dressing standpoint, these cause us the most trouble. Nevertheless the results have repaid us for the many hours devoted to dressing these patients. Figure 5a and b illustrates results of a hand burn which was treated by this method. The face burns do equally as well (Fig. 6a and b).

# THE SULFANILAMIDE OINTMENT TREATMENT OF BURNS IN MILITARY PRACTICE

The foregoing was written from the civilian surgeon's point of view and experience. In military and emergency practice, certain details of this (and other methods of) treatment will have to be sacrificed simply because of the rush of events, mass casualties, and insufficient personnel. It is our belief that the simple ointment method outlined here is worthy of consideration in any attempt at solution of the problem of how best to treat burns in military practice. In certain military zones of operation, it will be impossible to do much more than examine and treat rapidly the burned patients. Here, excision of bleb skin, etc. may be considered unwise and unnecessary. The military surgeon in the forward areas would do well simply to apply the sulfanilamide ointment (fatty base), preferably from tubes, spread it over the burn surface and cover the area with sterile gauze and bandage. If pressure dressing supplies (and time) are available, they should be used. This primary emergency dressing should be left in place until the patient reaches a base hospital, where it may be removed and definitive treatment carried out. It may prove to be unnecessary and unwise to remove this primary dressing before the optimum time, even to carry out a more detailed treatment. The main principle to be kept in mind is to cover the burned areas with sulfanilamide ointment and an occlusive dressing to prevent infection.

One of the chief disadvantages to the simple vaseline ointment treatment of burns in military practice may be its requirement on oral administration of the sulfonamides during the

initial days after the primary dressing, often in situations of war where the sulfonamides, water, and the personnel for administration may be altogether lacking.

In naval medical practice, sulfanilamide ointment (fatty base) may be stored in jars in certain quarters of the ship, to be applied by any available personnel (or the patient himself), if the sick bay is blown out.

For military purposes, the primary treatment of burns here outlined, if carried out only in its barest essentials, lends itself admirably to the problem of adaptability to any given military situation. Its use in aviators' hand and face burns should prove to be superior to any of the tanning methods. In short, for military use, the method is simple, inexpensive, requires limited equipment, personnel, and time, and offers promise of giving excellent functional results in the treatment of severe burns of every type.

## SUMMARY

A method of treatment of severe burns which employs sulfanilamide fatty base ointment as the primary dressing has been presented. In our hands it has given excellent results, with a low death rate. It is simple and easy to apply. Its relation to the problem of the treatment of burns in military surgery has been discussed.

## REFERENCES

- 1 ALLEN, H. S., and S. L. KOCH. *Surg Gyn Obst*, 1942, 74, 914.
- 2 ALLEN, J. G., OWENS, F. M., EVANS, B. H., and DRAGSTEDT, L. R. *Arch Surg*, 1942, 44, 819.
- 3 CANNON and COPE. *Ann Surg*, 1943, 117, 85.
- 4 GURD, F. B., ACKMAN, D., GERRIE, J. W., and PRITCHARD, J. E. *Ann Surg*, 1942, 116, 641.

# WOUND HEALING—EXPERIMENTAL AND STATISTICAL STUDY

## IV—Results

S ARTHUR LOCALIO M.D. WALTER CASALE M.D. and  
J WILLIAM HINTON M.D. F.A.C.S. New York, New York

In catgut sutured wounds it was found that during the lag period there were no statistically significant increases in tensile strength from one day to the next nor were there any significant decreases.

Among the nonabsorbable sutures statistically significant increases and decreases in tensile strength were observed in silk and cotton sutured wounds but only decreases in wire and nylon sutured wounds (see Graph 6). The lag period was longest for catgut and cotton sutured wounds, being of 4 days duration, for silk and wire sutured wounds, 3 days. For nylon the lag period was the shortest—2 days (see Tables IV, V, VI, VII and VIII).

There was one confusing factor. The lag period in cotton sutured wounds displayed a characteristic not seen during the lag period of any of the other nonabsorbable sutured wounds, namely a significant decrease in tensile strength by the 3d day, followed on the 4th day by a nonsignificant increase and then a significant increase. Thus there was an interval of 1 day in which there was a nonsignificant increase in tensile strength, until a significant increase was noted.

On the other hand in all wounds sutured with any of the other nonabsorbable materials there was a significant decrease in tensile strength characterizing the end of the lag period, followed immediately by a significant increase.

Since the same technique was used throughout the experiment obviously the only vari-

able that could exert a causative influence was the type of suture material used. From the point of view of shortening the lag period in order to accelerate final healing the results so far would seem to indicate that a nonabsorbable suture is preferable to catgut and of the nonabsorbable sutures it would seem that nylon is to be preferred over the others.

Howes and Harvey<sup>1</sup> have indicated that interpretation of the tensile strength of wounds during the lag period is open to question since the results obtained are dependent upon the type of suture material used. It appears to us that an increase in tensile strength associated with a particular type of suture material should be taken into consideration.

In the groups studied the lowest point on the curve of tensile strength occurred at the termination of the lag period (see Graph 6). Following this period the gain in tensile strength was progressive and was coincidental with proliferation of connective tissue. This was to be expected since this is the interval just preceding the beginning of fibroplasia, and probably at this time also the suture material has been weakened by the reaction of the wounds. Moreover the tissues adjacent to the suture material have probably suffered from trauma. Tissue reaction is decreased and holding power of the tissues is lessened.

The limiting factor in testing the tensile strength of wounds in the post-lag period by the method outlined is the tensile strength of the pelvic peritoneum. We have indicated that after a certain number of days, disruption no longer occurred in the wound but in the pelvic peritoneum. As soon as this point was reached the tensile strength of the wound was no longer measurable. It is obvious that

From the Departments of Surgery and Pathology of the New York Post Graduate Medical School of Columbia University.

This work has been made possible by grants from Mrs. O. Macculloch Miller, Mr. Stewart Hoppe and the Surgical Fund of the New York Post-Graduate Medical School.

Parts I and II are to appear in later issues of International Abstract of Surgery. Part III, appears in SCIENCE, Gynecol. Out. to Obstetrics, 64, 77, 245-49.

Howes, E. L., and Harvey, R. C. Ann. Surg. 55: 127-32 (1912).  
Campbell, W. G. to appear in Part III.



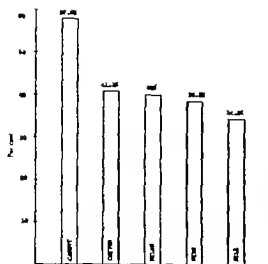


Chart 2. Percentage of wound disruptions

of healing of cotton sutured wounds with respect to tensile strength was entirely different from that of wounds sutured with any of the other materials. The fact that cotton had the second highest percentage of wound disruptions seems to lend emphasis to our previous statement that possibly the lag period of cotton sutured wounds was the same length as that of catgut sutured wounds.

Tables V, VI, VII, VIII and IX present the results of a day by day analysis of differences in mean tensile strength of wounds during and directly following the lag period.

In assembling these data, care had to be taken in computing the mean tensile strengths in order to be certain that values for wound disruptions only were included. As the days passed wound disruptions became fewer and

\*Chart appears in Part II, Internal Abstract Book, December 1943

TABLE IX.—WOUND DISRUPTIONS IN PER CENTAGE OF TOTAL DISRUPTIONS

Suture material	Total number of disruptions*	Total number of wound disruptions	Wound disruptions per cent
Catgut	66	47	69
Cotton	36	23	63
Nylon	35	21	60
Wire	33	21	63
Silk	30	21	70

\*Equal to number of animals tested

fewer regardless of the type of suture material used so that by the 5th day there were not sufficient data available to make possible tests for significance of differences in mean tensile strength.

Before we attempt to draw any conclusions from our results, a word to the method of reading these tables may not be amiss.

Let us consider Table V, which is typical. Ten tests are presented. The first column indicates that we are testing the mean pressure necessary to cause disruption in catgut sutured wounds on the 1st postoperative day against the mean pressure necessary to cause disruption in silk sutured wounds on the 1st postoperative day, catgut against wire, catgut against cotton, catgut against nylon, and so on.

On the 1st postoperative day the mean tensile strength of wounds sutured with any of the nonabsorbable materials was significantly greater than the mean tensile strength of wounds sutured with catgut. Furthermore among the nonabsorbable sutured wounds, although differences in mean tensile strength were observed, in no case were these differences significant.

On the 3d postoperative day (Table VI) only nylon sutured wounds showed a mean tensile strength not significantly greater than that of catgut sutured wounds. On this day the experiments showed that the mean tensile strength of silk sutured wounds was significantly greater than that of wounds sutured with any of the other nonabsorbable materials, and there were no significant differences in mean tensile strength among wounds sutured with wire, cotton or nylon.

On the 3d postoperative day, there were some reversals in the relationship of tensile strengths (see Table VII). Whereas on the 2d day the mean tensile strength of silk, wire or cotton sutured wounds was significantly greater than that of catgut sutured wounds, and the mean tensile strength of nylon sutured wounds was not significantly greater than that of catgut sutured wounds, the 3d day showed the mean tensile strength of nylon sutured wounds to be significantly greater than that of catgut sutured wounds, while the mean tensile strength of wounds sutured with the other nonabsorbable materials was not significantly

TABLE IV A—DATA ON WOUNDS SUTURED WITH CATGUT—NO 0000 PLAIN, AND NO 0000 CHROMIC

Days post operative	Number of animals tested	Pressure—mm mer cury—necessary to cause disruption	Mean pressure necessary to cause disruption mm mer cury	Site of disruption	Culture	Days post operative	Number of animals tested	Pressure—mm mer cury—necessary to cause disruption	Mean pressure necessary to cause disruption mm mer cury	Site of disruption	Culture
1	6 Plain	43	44	Wound	None taken	1	Chromic	52	5	Wound	Negative
	Plain	44		Wound	Negative		Chromic	68		Wound	Nonhemolytic streptococcus
	Plain	44		Wound	Negative		Chromic	74		Wound	Negative
	Chromic	44		Wound	Negative	2	6 Plain	93	5	Pelvis	Nonhemolytic streptococcus and Staphylococcus aureus
	Chromic	44		Wound	Staphylococcus aureus		Plain	8		Wound	Negative
	Chromic	46		Wound	Negative		Plain	87		Wound	Nonhemolytic streptococcus
2	6 Plain	40	47	Wound	Nonhemolytic streptococcus		Chromic	44		Iliac	Negative
	Plain	49		Wound	Negative		Chromic	86		Wound	Green staphylococcus
	Plain	51		Wound	Negative		Chromic	86		Pelvis	Negative
	Chromic	44		Wound	Negative	3	6 Plain	84	93	Iliac	Negative
	Chromic	44		Wound	None taken		Plain	85		Iliac	Negative
	Chromic	44		Wound	None taken		Plain	85		Iliac	Negative
3	6 Plain	4	47	Wound	Negative		Chromic	92		Pelvis	Staphylococcus aureus
	Plain	50		Wound	Negative		Chromic	107		Pelvis	Negative
	Plain	63		Wound	Negative		Chromic	97		Pelvis	Negative
	Chromic	42		Wound	Negative	4	Plain	89	92	Wound	Negative
	Chromic	55		Wound	Negative		Plain	86		Pelvis	Negative
	Chromic	46		Wound	Negative		Plain	93		Pelvis	Negative
4	7 Plain	34	35	Wound	None taken		Chromic	91		Pelvis	Colon bacillus
	Plain	28		Wound	None taken		Chromic	111		Pelvis	Negative
	Plain	45		Wound	Negative		Chromic	82		Iliac	Negative
	Plain	33		Wound	Progenetic Staphylococcus aureus	5	1 Plain	99	97	Pelvis	Negative
	Chromic	33		Wound	Negative		Plain	105		Pelvis	Nonhemolytic streptococcus
	Chromic	57		Wound	Negative		Chromic	86		Pelvis	Negative
5	6 Plain	44	75	Wound	None taken	6	2 Plain	80	88	Iliac	Negative
	Plain	64		Wound	Staphylococcus aureus		Chromic	96		Pelvis	Negative
	Plain	66		Wound	Negative	31	2 Plain	103	106	Pelvis	Negative
	Chromic	61		Wound	Negative		Chromic	110		Pelvis	Negative
	Chromic	59		Wound	Negative	45	2 Plain	97	98	Pelvis	Negative
	Chromic	55		Wound	Negative		Plain	100		Pelvis	Negative
6	6 Plain	66	75	Wound	Negative	62	2 Plain	100	99	Pelvis	Negative
	Plain	61		Wound	Negative		Chromic	98		Pelvis	Negative
	Plain	98		Wound	Negative						



TABLE A.—DATA ON WOUNDS SUTURED WITH SILK—B(DEKNATEL)

Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Cause	Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Cause
	5	6	77	Wound	Negative		5	93	99	Peria	Negative
		79		Wound	Negative			100		Peri	Negative
		79		Wound	Negative			104		Peria	Negative
		6		Wound	Negative			105		Peria	Negative
				Wound	Negative			97		Peri	Negative
		102	94	Wound	Negative	5		109	104	Peria	Negative
		6		Wound	Negative			109		Peria	Negative
		99		Wound	Negative			100		Peria	Negative
		93		Wound	Negative			93		Peria	Negative
		94		Wound	Negative					Peria	Negative
	6	99	99	Wound	Negative			96	100	Peria	Negative
		43		Wound	Negative			96		Peria	Staphylococcus aureus
		99		Wound	Negative			95		Peria	Negative
		42		Wound	Negative					Peria	Negative
		99		Wound	Staphylococcus aureus			100		Peria	Negative
	7	76	96	Wound	Negative			100	104	Peria	Negative
		84		Wound	Negative			76		Peria	Negative
		85		Wound	Negative			90		Peria	Negative
		101		Peria	Negative			100		Peria	Negative
		84		Wound	Negative			104		Peria	Negative
	8	24	98	Dist	Xanthomolytic disruption			105	104	Peria	Staphylococcus aureus
		96		Peria	Negative			104		Peria	Negative
		8		Wound	Negative			104		Peria	Negative
		95		Peria	Negative			102		Peria	Negative
		84		Dist	Negative			104		Peria	Negative
6		104	99	Peria	Negative	42		104	100	Peria	Negative
		104		Peria	Negative			97		Peria	Negative

greater than that of catgut sutured wounds. On this day (as on the 2d postoperative day) the mean tensile strength of silk sutured wounds was significantly greater than that of wounds sutured with wire cotton or nylon.

On the 3d postoperative day there was no significant difference in mean tensile strength between wire sutured wounds and cotton sutured wounds but the mean tensile strength of nylon sutured wounds was significantly greater than that of wire or cotton sutured wounds.

On the 4th postoperative day the picture was the same as on the 1st day (see Table VIII).

On the 5th postoperative day it was impossible to make tests of significance in mean tensile strength except in the case of catgut cotton because by this day so few wounds sutured with nonabsorbable materials were disrupting. All catgut sutured wounds on this day however disrupted. In the catgut-cotton test it was demonstrated that, as on the 4th day the mean tensile strength of cotton su-

# LOCALIO ET AL WOUND HEALING

381

TABLE VI A—DATA ON WOUNDS SUTURED WITH COTTON—NO 000 (GUILDBROD)

Days postoperative	Number of animals tested	Pressure mm mercury—necessary to cause disruption	Mean pressure necessary to cause disruption mm mercury	Site of disruption	Culture	Days postoperative	Number of animals tested	Pressure mm mercury—necessary to cause disruption	Mean pressure necessary to cause disruption mm mercury	Site of disruption	Culture
1	5	6	64	Wound	None taken	6	5	101	92	Pelvis	Negative
		67		Wound	Negative			89		Pelvis	Negative
		65		Wound	Negative			111		Pelvis	None taken
		60		Wound	Negative			87		Pelvis	Negative
		60		Wound	Negative			0	100	Pelvis	Negative
	5	71	4	Wound	None taken		5	105		Pelvis	Negative
		71		Wound	None taken			100		Pelvis	Negative
		71		Wound	None taken			95		Pelvis	Negative
		70		Wound	Negative			111		Pelvis	Negative
		61		Wound	Negative			85		Pelvis	Negative
	5	50	60	Wound	None taken	4	5	121	101	Pelvis	Negative
		61		Wound	Nonhemolytic streptococcus			95		Pelvis	Negative
		61		Wound	None taken			0		Pelvis	Streptococcus (alpha type)
		60		Wound	None taken			99		Pelvis	Negative
	4	84	71	Wound	None taken		5	104	93	Pelvis	Negative
		65		Wound	Negative			8		Pelvis	Negative
		67		Wound	None taken			95		Pelvis	None taken
		69		Wound	Negative			95	95	Pelvis	Negative
		81		Wound	Negative	11	2	103	101	Pelvis	Negative
		89		Wound	Negative			103		Pelvis	Negative
	5	85	87	Wound	Negative	21	2	100	102	Pelvis	Negative
		92		Wound	Negative			105		Pelvis	Negative
		83		Pelvis	Negative	31	2	101	101	Pelvis	Negative
		88		Pelvis	Negative			106		Pelvis	Negative
	6	87	92	Pelvis	Negative	45	2	99	103	Pelvis	Negative
		94		Pelvis	Negative	62	3	105		Pelvis	None taken

tured wounds was significantly greater than that of wounds sutured with catgut (Table XIV)

The data presented in Tables X, XI, XII, XIII and XIV are summarized in Table XV. On the 1st and 2d postoperative days the mean tensile strength of catgut sutured wounds was significantly less than the mean tensile strength of silk sutured wounds. On the 3d day the mean tensile strength of catgut sutured wounds was not significantly greater than the mean tensile strength of silk sutured wounds. On the 4th day the relationship was

the same as on the 1st and 2d days and on the 5th day there were not sufficient data to make a test possible.

The group of tests shows that during the lag period the mean tensile strength of catgut sutured wounds was always less than that of materials, except on the 3d day, when the mean tensile strength of silk sutured wounds dropped to a level of less, but not significantly less than that of catgut.

The remaining tests concern the nonabsorbable sutures. It will be seen that in general

TABLE VII A—DATA ON WOUNDS SUTURED WITH WIRE—  
No. 36 STAINLESS STEEL ALLOY (PILLINGS)

Days postoperative	Number of animals tested	Pressure (mm. mercury) necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture	Days postoperative	Number of animals tested	Pressure (mm. mercury) necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture
		67	85	Wound	Negative			81	96	Palate	Negative
		67		Wound	Negative			87		Palate	Negative
		85		Wound	Negative			8		Palate	Negative
		69		Wound	Negative			70	96	Palate	Negative
				Wound	Negative			87		Palate	Negative
		79	64	Wound	Negative			96		Palate	Negative
		85		Wound	Negative			96		Palate	Negative
		79		Wound	Negative			96		Palate	Negative
		83		Wound	Negative			96		Palate	Negative
		6		Wound	Staphylococcus aureus			100	91	Palate	Negative
								99		Palate	Negative
								80		Palate	Negative
								80		Palate	Negative
		83	81	Wound	Negative			96	100	Palate	Mendococcus streptococcus
		80		Wound	Mendococcus streptococcus			96		Palate	Kona isolat
		83		Wound	Staphylococcus aureus			96		Palate	Kona isolat
		80		Wound	Negative			96		Palate	Kona isolat
		83		Wound	Negative			100	80	Palate	Kona isolat
				Wound	Negative			100		Palate	Kona isolat
		79		Wound	Negative			100		Palate	Kona isolat
		77		Wound	Negative			80		Diast	Negative
		76		Wound	Negative			83	82	Diast	Negative
		79		Wound	Negative			82		Diast	Negative
		85	87	Wound	Negative	21		83	106	Diast	Negative
		64		Palate	Negative	21		106		Palate	Negative
		8		Diast	Negative	21		107	100	Palate	Negative
				Stomach	Negative	43		100		Diast	Negative
		85		Diast	Negative			70	105	Palate	Negative
6		114	96	Palate	Negative	60		100		Palate	Negative
		67		Palate	Negative					Palate	Negative

there were no significant differences in mean tensile strength of wounds sutured with these materials. However in the tests of silk against the other nonabsorbable sutures, on the 2d and 3d postoperative days the mean pressures necessary to cause disruption in silk sutured wounds were significantly different from those necessary to cause disruption in wire, nylon, and cotton sutured wounds. On these days, as shown in Graph 6 the disruption pressures for silk sutured wounds varied far more widely than did the disruption pressures for any of

the other materials. It should be noted also that the mean disruption pressure for silk sutured wounds was not significantly less than that for catgut sutured wounds on the 3d postoperative day even with the great decrease in the pressure which is necessary to cause disruption in silk sutured wounds on that day.

From the results of these tests, we may conclude that the use of catgut results first, in a longer lag period and second in weaker wounds during the lag period.

TABLE VIII A.—DATA ON WOUNDS SUTURED WITH NYLON—B (DEKNATEL)

Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption mm. mercury	Site of disruption	Culture	Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture
1	5	47	65	Wound	Negative	6	5	80	92	Wound	Negative
		70		Wound	Negative			100		Pelvis	Negative
		71		Wound	Negative			83		Iliac	Staphylococcus aureus
		67		Wound	Negative			103		Pelvis	Negative
		68		Wound	Negative			108		Pelvis	Negative
2	5	55	58	Wound	Negative	7	5	100	99	Pelvis	Negative
		73		Wound	Negative			100		Pelvis	Negative
		69		Wound	Negative			83		Pelvis	Negative
		49		Wound	Negative			81		Iliac	Negative
		46		Wound	Negative			97		Iliac	Negative
3	5	66	70	Wound	Negative	8	5	84	86	Iliac	Negative
		96		Wound	Negative			84		Iliac	Negative
		69		Wound	Negative			103		Pelvis	Staphylococcus aureus
		66		Wound	Negative			100		Pelvis	Negative
		97		Wound	Negative			102		Pelvis	Negative
4	5	106	84	Wound	Negative	9	5	100	101	Pelvis	Staphylococcus aureus
		75		Wound	Negative			100		Pelvis	Negative
		82		Wound	Negative			101		Pelvis	Negative
		75		Wound	Negative			102		Pelvis	Negative
		80		Wound	Negative			103		Pelvis	Staphylococcus aureus
5	5	105	93	Pelvis	Negative	13	2	105	103	Pelvis	Negative
		89		Wound	Negative			110		Pelvis	Negative
		91		Pelvis	Negative			105		Pelvis	Negative
		91		Pelvis	Negative			105		Pelvis	Negative
		88		Iliac	Negative			105		Pelvis	Negative
6	5	90	92	Iliac	Negative	31	2	105	105	Pelvis	Negative
		94		Iliac	Negative			105		Pelvis	Negative
		94		Iliac	Negative			105		Pelvis	Negative
		94		Iliac	Negative			105		Pelvis	Negative

The significant finding here is that there is no real basis for preferring one nonabsorbable suture over another—as far as tensile strength of wounds during the first 5 postoperative days is concerned. However, the use of any of these nonabsorbable sutures resulted in stronger wounds than were obtained with catgut.

From the data presented in Table XV we are able to make some further comments as to the length of the cotton lag period. On the 4th postoperative day, the "extra" day in the

cotton lag period, the mean tensile strength of cottonsutured wounds was significantly greater than that of catgut sutured wounds. The important aspect is tensile strength rather than length of lag period, so that when comparing two suture materials, possibly with lag periods of equal length, one of which results in wounds with a greater tensile strength than does the other, it would appear that that material which more rapidly brings about an increase in tensile strength of the wound is preferable. Although these data do not enable us to deter-

TABLE X.—ANALYSIS OF TESTS PERFORMED 1ST DAY AFTER OPERATION TO ASCERTAIN WHETHER THE DIFFERENCES IN MEAN TENSILE STRENGTH NECESSARY TO DISRUPT WOUNDS ARE SIGNIFICANT

Test	Mean pressure, mm. mercury necessary to cause disruption of wound					Number of animals tested					Degrees of freedom	Value of "t" at critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon			
Catgut silk	44	77									40		S
Catgut wire	44		64								40		S
Catgut cotton	44			64		6							S
Catgut nylon	44				64	6				1	5		S
Silk wire		77	64										N.S.
Silk cotton		77		64									N.S.
Silk nylon		77			64						8		N.S.
Wire cotton			64								1		N.S.
Wire nylon			64		64					6			N.S.
Cotton nylon				64	64					1			N.S.

\* Significant, N.S. not significant; X.D. no difference.  
 \*The critical value of "t" taken to be at the 5% level of significance. At this level difference in mean pressure as great, or greater than that observed may be considered as due to chance, time at time.

mine definitely the length of the cotton lag period they do enable us to evaluate the importance of this "peculiar characteristic of cotton sutured wounds, namely that their tensile strength is greater than that of catgut sutured wounds.

The next matter that comes up for consideration is a comparison of wound strengths during the postlag period.

From the 4th to the 7th day the mean pressures necessary to cause disruption in catgut

sutured wounds were on the average approximately 30 millimeters of mercury less than those necessary for disruption of wounds sutured with the nonabsorbable materials—or approximately one third of the pressure necessary to disrupt the abdomens of healthy rats. Here we have further evidence that nonabsorbable sutures are preferable to catgut. This statement is based upon the data presented in Table XVI and Graph 6. Table XVI is a summary of data on mean pressures which are

TABLE XI.—ANALYSIS OF TESTS PERFORMED 2D DAY AFTER OPERATION

Test	Mean pressure, mm. mercury necessary to cause disruption of wound					Number of animals tested					Degrees of freedom	Value of "t" at critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon			
Catgut silk	47	96											S
Catgut wire	47		64										S
Catgut cotton	47			74									S
Catgut nylon	47				70								N.S.
Silk wire		96	64								8		S
Silk cotton		96									6	5	S
Silk nylon		96			70					1			S
Wire cotton			64										N.S.
Wire nylon			64		70								S
Cotton nylon				74	70				1	1		1	

\* Significant, N.S. not significant.  
 \*The critical value of "t" taken to be at the 5% level of significance. At this level difference in mean pressure as great, or greater than that observed, may be considered as due to chance, time at time.

TABLE XII — ANALYSIS OF TLSTS PERFORMED 3D DAY AFTER OPERATION

Test	Mean pressure mm mercury necessary to cause disruption of wound					Number of animals tested					t	Degrees of freedom	Value of "t" not critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	47	40												
Catgut wire	4		52			6	6				1.3	10	3.2	N S
Catgut cotton	47			60		6		5			8	0	3.3	
Catgut nylon	4				70	6			5		2.2	0	3.3	N S
Silk wire		40	52							5	5.2	0	3.3	S
Silk cotton		40		60			6	5			10.3	0	3.3	S
Silk nylon		40			79		6		5		40.8	0	3.3	S
Wire cotton			52	60						5	26.3	0	3.3	S
Wire nylon			52		70		5		5		1.0	8	3.4	N S
Cotton nylon			52		60		5		5		15.3	8	3.4	S
					60				5	5	11.6	8	3.4	S

S Significant, N S not significant

\*The critical value of t is taken to be at the .05 level of significance. At this level a difference in mean pressure as great, or greater than that observed, may be considered as due to chance 1 time in 100.

shown in Tables IV-A, V-A, VI-A, VII-A and VIII-A. The means presented in this table were obtained by averaging all pressures necessary to cause disruption, regardless of the site of disruption. The Tables IV-A, V-A, VI-A, VII-A, and VIII-A indicate which of these means represent disruption in the wound only, which represent disruption in the wound and in other areas in the pelvic peritoneum, and which indicate disruption in the pelvic peritoneum only.

It was found that the average pressure necessary to cause disruption in the abdomen

of the control rats was 98 millimeters  $\pm 5.2$  millimeters. This value may be regarded as the mean tensile strength of the abdomen of a healthy rat.

As time passed, it was observed that the pressure necessary to cause disruption in the abdomens of the experimental animals increased (see Table XVI). In fact, after a time, the mean pressure necessary to cause disruption attained a level at least as high as that found for the controls. At this stage the operative wounds had healed sufficiently so that the abdomens of these animals were

TABLE XIII — ANALYSIS OF TESTS PERFORMED 4TH DAY AFTER OPERATION

Test	Mean pressure mm mercury necessary to cause disruption of wound					Number of animals tested					t	Degrees of freedom	Value of "t" not critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	38	82												
Catgut wire	38		75			7	5				8.4	10	3.2	S
Catgut cotton	38			71		7		5			7.9	10	3.2	S
Catgut nylon	38				84	7			5		6.3	10	3.2	S
Silk wire		82	75							5	7.0	10	3.2	S
Silk cotton		82		71			5	5			3.2	8	3.4	N S
Silk nylon		82			84					5	3.1	8	3.4	N S
Wire cotton			75	71						5	3	8	3.4	N S
Wire nylon					84		5			5	1.1	8	3.4	N S
Cotton nylon					84				5	5	1.5	8	3.4	N S
					71				5	5	2.0	8	3.4	N S

S Significant, N S not significant

\*The critical value of t is taken to be at the .05 level of significance. At this level a difference in mean pressure as great, or greater than that observed, may be considered as due to chance 1 time in 100.

TABLE XIV—ANALYSIS OF TESTS PERFORMED 5TH DAY AFTER OPERATION

Test	Mean pressure, in mm mercury necessary to cause disruption of wound					Number of animals tested					t	Degree of freedom	Value of "t" at critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	34	8												N S D
Catgut wire	34		8			6								S
Catgut cotton	34			64		6					2	7		S
Catgut nylon	34				64	6								N S D
Silk wire			24											N S D
Silk cotton				24										N S D
Silk nylon		8			64									N S D
Wire cotton			24	64										N S D
Wire nylon					64									N S D
Cotton nylon				64	64				2					N S D

S Significant, N S not significant; N S D not sufficient data to test difference in means.

\*Since there are so few observations, there is not sufficient information on which to make statistical test. The best that can be done is interpretation of these results in so far as difference is indicated by the experimental figures.

comparable in strength to the abdomens of healthy rats. At this point the abdomen of an experimental rat may be considered to be

TABLE XV—SUMMARY OF ANALYSIS OF SIGNIFICANCE OF DIFFERENCES IN MEAN STRENGTH NECESSARY TO CAUSE WOUND DISRUPTION DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Test	Days after operation				
Catgut silk	S L	S L	N S D	S L	N S D
Catgut wire	S L	S L	N S L	S L	N S D
Catgut cotton	S L	S L	N S L	S L	S L
Catgut nylon	S L	N S L	S L	S L	N S D
Silk wire	N S D	S D	S L	N S D	N S D
Silk cotton	N S D	S D	S L	N S D	N S D
Silk up line	N S D	S D	S L	N S L	N S D
Wire silk	N S L	S L	S D	N S L	N S D
Wire cotton	N S D	N S L	N S L	N S D	S D
Wire nylon	No diff	N S D	S L	N S L	N S D
Cotton silk	N S L	S L	S D	N S L	N S D
Cotton wire	N L	N S D	N S D	N S L	N S D
Cotton nylon	N S L	N S D	S L	N S L	N S D
Nylon silk	N S L	S L	S D	N S D	N S D
Nylon cotton	N S D	N S L	S D	N S D	N S D
Nylon wire	No diff	N S L	S D	N S D	N S D

S L, significantly less; N S L, not significantly less; S D, significantly greater; N S D, not significantly greater; N S D, not sufficient data to test difference in means.

"normal" with respect to tensile strength. The fact that an abdomen is able to withstand a pressure as great as that which the abdomen of a healthy animal can stand before disrupting does not necessarily imply from a clinical point of view that the wound has healed but it has improved sufficiently so that it no longer constitutes a weak area in the abdominal wall. When the mean pressure necessary to cause disruption in the abdomens of experimental rats is no longer significantly less than the mean pressure necessary to cause disruption in the abdomens of the control rats, or when the mean pressure is equal to or greater than, the mean pressure necessary to cause disruption in the abdomen of the healthy animals then from the point of view of tensile strength, the wounds may be considered to be healed.

Table XVII presents an analysis of differences between mean pressures necessary to cause disruption in the abdomens of experimental rats and mean pressures necessary to cause disruption in the abdomens of healthy rats.

The mean pressure necessary to disrupt abdomens of experimental animals whose wounds were sutured with catgut was significantly less than the mean pressure necessary to disrupt the abdomens of the control rats up to the 8th postoperative day. A similar condition existed until the 4th day in silk and nylon and until the 5th day in wire and cotton.





TABLE XVIII.—LATENT AND "HEALING" PERIODS OBSERVED IN RATS SUTURED WITH VARIOUS MATERIALS

Suture material	Length of latent period (days)	Length of "healing" period (days)
Catgut		
Silk		
Wool		1
Cotton	4	3
Nylon		1

\*The length of the cotton latent period is subject to two interpretations. As explained at the text, it may be considered as 4 or 5 days.

"healing" period were not great enough so that one material should be preferred over another. Between silk and nylon there was no difference nor was there any difference between wool and cotton, but between the former and latter groups there was a difference of 1 day in the length of the "healing" period.

An interesting relationship exists between the length of the lag period in increase in tensile strength and the length of the "healing" period just discussed. Table XVIII shows the lengths of these two periods in days for the 5 different suture materials used.

The interpretation of this relationship which may be expressed in terms of the correlation coefficient,  $r$ , depends upon our interpretation of the length of the lag period in increase in tensile strength of cotton sutured wounds. As mentioned previously, the length of the cotton lag period could not be clearly determined. According to the interpretation this period could have been 3 days long or 4 days long.

The correlation between the length of the lag period and the length of the "healing" period was (a) .7319 if the length of the cotton lag period is taken as 4 days and, (b) .8660 if the period is taken to be 3 days.<sup>1</sup>

We may consider that the length of the healing period is dependent upon the length of the lag period. (It is impossible for the length of the lag period to be dependent upon

the length of the "healing" period.) The longer the lag period the longer the period until the mean tensile strength of the abdomens of experimental rats is no longer significantly less than the mean tensile strength of abdomens of control rats. Therefore we have another reason for regarding catgut to be unfavorable light. Catgut sutured wounds clearly had the longest lag period in increase in tensile strength and also the longest "healing" period with respect to tensile strength.

The results of our experiments lead us to the conclusion that the nonabsorbable sutures are superior to the absorbable suture with respect to tensile strength and that, in this same respect, one nonabsorbable suture is not to be preferred over another. This conclusion is based upon the following observations:

1. The lag period—that is, the period of delay in increase in tensile strength—was clearly the longest when catgut was the suture material used. The mean tensile strength of wounds sutured with this material was generally significantly less than that of wounds sutured with a nonabsorbable suture.

2. The use of catgut resulted in a greater total number of wound disruptions over the entire period of increase in tensile strength than was the case when the nonabsorbable sutures were used.

3. When a nonabsorbable suture was used the mean tensile strength of the abdomens of the experimental animals reached a level not significantly less than that of the control animals (that is, they became normal with respect to tensile strength) at an earlier date than was the case with catgut.

4. We found a high correlation between the length of the lag period in increase in tensile strength and the "healing" period with respect to tensile strength. The length of the "healing" period is dependent upon the length of the lag period. The longer the lag period, the longer the healing period.

Especially nonabsorbable sutures displayed no important differences among themselves with respect to the points considered.

<sup>1</sup>These coefficients were computed by the product moment formula See Applied General Statistics, Cramton and Cramton, Chicago 22.

# REASONS WHY THE ORTHODOX IS BETTER THAN THE KENNY TREATMENT OF POLIOMYELITIS

J ALBERT KEY, M D, F A C S, St. Louis, Missouri

**I**N the lay press and on the radio the Kenny treatment of poliomyelitis is being hailed as the dawn of a new era in the treatment of this disease and the orthodox treatment has been grossly misrepresented. It is thus desirable that the orthodox treatment be given a fair hearing. In this paper the two methods are described and the reasons for preferring the orthodox treatment are given.

Proponents of the Kenny method claim that the orthodox treatment is wrong because the true symptoms of the disease have never been recognized until Miss Kenny discovered them (6) and consequently we could not treat the true disease because we had never seen it. These symptoms are muscle spasm, inco-ordination, and mental alienation, and it is stated that these are Miss Kenny's contributions to the symptomatology of the disease. If we analyze these symptoms we find that they are not conditions which have not been recognized and treated by surgeons for a great many years, but they are new names for conditions that are well known to every surgeon who has to do with the treatment of patients with infantile paralysis. For instance, muscle spasm includes the conditions which we call tenderness, stiffness, and rigidity or early contracture of muscles, and we believe that they, with the pain, are caused by spinal and meningeal inflammation. Miss Kenny believes that a local condition (apparently an acute inflammation) is present in the muscle and that this is the cause of the spasm. There is no evidence that there is any disease in the muscle in poliomyelitis. We have treated this condition with uniform success by immobilization until the pain and tenderness subside.

Inco-ordination includes conditions which we have recognized and treated under two terms, one is mass movements and the other is trick movements or muscle substitution. We

prefer to use the terms which we have used in the past, as they are more descriptive and cause there is no true inco-ordination in the medical sense in infantile paralysis. We have treated this by muscle training.

The same is true of mental alienation. This includes muscles which are partially paralyzed and those which are temporarily paralyzed. There is nothing new about the recognition of this symptom, except the term "mental alienation," which we believe is not a good term for the condition present. We have treated this by muscle training.

It thus appears that Miss Kenny's new concept of the disease is not new at all and that her contribution to the symptomatology of the disease is the giving of new names to well known symptoms, all of which have been recognized and treated by orthodox methods.

In order that we may compare the two methods, it is first in order to describe very briefly the orthodox and the Kenny methods of treatment of the disease. The orthodox method will be given first. It has for its object the saving of life, maintenance of nutrition, relief of pain, protection of paralyzed muscles, maintenance of circulation, prevention of deformity, restoration of function and the rehabilitation of the patient.

The treatment is best described under the four recognized stages of the disease: the acute febrile stage, the stage of tenderness and early contracture, the convalescent stage, and the chronic stage.

*The acute febrile stage* The acute febrile stage lasts but a few days. During this period paralysis appears and, as a rule, progresses rapidly until the disease subsides. The fever usually subsides within a day or two after the paralysis begins. In this stage we are dealing with a patient who is afflicted with an acute infectious disease. The treatment is largely medical, and the disease is self-limited. There is no specific treatment, and it is not possible

to predict how extensive or how permanent the paralysis will be. However we believe that other things being equal, the less the patient is disturbed the better will be his resistance to the disease. Consequently the patient is left severely alone and kept as quiet and as comfortable as possible. No exercises or physical therapeutic measures are prescribed during this period.

*The stage of tenderness and early contracture*  
The stage of tenderness and early contracture begins when the fever has subsided—that is within a day or two after the paralysis has appeared. During this stage the neck and spine are stiff and some of the muscles are tender and painful when stretched. There is a variable amount of pain in the extremities and the nonparalyzed tender muscles tend to contract and produce deformities and to stretch the muscles which have been paralyzed by the disease. Consequently we keep the patient in bed and immobilize the paralyzed extremities in splints or casts in the physiological position. These splints or casts tend to relieve the pain and tenderness in the extremities and tend also to prevent deformities and the stretching of paralyzed muscles. They are not as a rule left on continuously but are removed once or twice a day and the extremities are moved passively through whatever range of motion is possible without causing undue pain to the patient. This is done to keep the joints free and to prevent shortening of the muscles of the extremity.

Some orthopedic surgeons also use hot packs or warm baths during this stage for the relief of the pain but these are not used routinely. It is also to be noted that the splints are used only in cases in which they are indicated to relieve pain and muscle tenderness, to prevent contracture and to protect paralyzed muscles. The extremities which are not involved are not splinted. During this stage no massage or active movements of the paralyzed extremities are permitted because it has been found that massage and active movement tend to prolong the tenderness and to increase the pain and contractures.

In paralyzed patients the period of tenderness and contracture usually lasts from 3 to 6 weeks or longer but rarely over 3 months

under orthodox treatment. If the patient is not paralyzed and the tenderness is slight and there is no tendency to contracture no splints are applied and no treatment is indicated, other than to permit the patient to convalesce from the acute febrile disease and then gradually resume his normal activities.

*The convalescent stage*  
The convalescent stage begins when the stage of tenderness and contracture has passed, and it persists for from a few months to two years. During this period the paralyzed muscles tend to recover their powers spontaneously unless the anterior horn cells in the spinal cord which supply them with their motor impulses have been killed by the disease. These muscles can be divided into three groups: (1) The motor nerve cells of the muscles are killed by the disease and the muscles are permanently paralyzed. (2) The motor nerve cells of the muscles are not killed by the disease but they are so severely injured that they are not able to function. These cells will recover and again send motor impulses to the muscles and the muscles will regain their power. And (3) some of the motor nerve cells which supply the muscles are killed and others are injured and will recover and again send motor impulses to the muscles and the muscles will regain part of their power but will not become normal. The permanent loss of power in a given muscle will vary directly with the percentage of its motor cells which are killed.

Since it is not possible to differentiate the permanent from the temporarily and partially paralyzed muscles, except by noting the recovery of the latter two groups, all paralyzed muscles are treated by muscle training and this treatment is begun as soon as possible after the pain and tenderness have subsided. If the treatment is followed by reappearance of the pain and tenderness the muscles are again put at rest for a few days and then the treatment is resumed.

It is my belief that if deformities are prevented the residual paralysis in poliomyelitis is dependent upon the death of motor cells supplying the muscles and that most of the recovery from the disease is spontaneous and is not greatly influenced by treatment. This recovery from the temporary paralysis is not sudden but occurs gradually as the patient's

pain and stiffness disappear, and he repeatedly attempts to use his extremities. It is thus evident that I believe that the chief value of muscle training is that deformities are prevented or corrected and the temporarily paralyzed muscles are protected from stretching and fatigue while they are regaining their power, and that the maximum power is developed in that portion of the partially paralyzed muscles which still retains a motor nerve supply.

In other words, in the spinal type of the disease there is no evidence that there is any permanent damage to the central nervous system other than the destruction of the motor cells. The anatomical damage to the nervous system is permanent, but the physiological damage is temporary and disappears spontaneously, and treatment may hasten, but is not responsible for, the recovery of function in anatomically intact neurones. It is because I hold this opinion that I have been misquoted as saying that "no treatment is any good."

Many orthopedic surgeons believe that connections between the cerebral cortex and the motor cells are damaged and that the central nervous system will not recover spontaneously, but that the patient can, by concentration on a given movement, either restore old pathways which would not be opened spontaneously or can actually develop new pathways to the muscles which perform the movement. For instance, Lovett (3) defined muscle training as "fundamentally an effort to restore a cerebral motor impulse to a muscle, an impulse which has been either impaired or lost during the acute stage of poliomyelitis" and states that it aims at "establishing a better co-ordination between the remaining nerve fibers supplying the affected muscle and second at securing contraction of the desired muscle, however feeble, which is of course the best possible treatment of the muscle itself."

However, regardless of our views we all use muscle training, but vary as to how much of the improvement we ascribe to the treatment and how much to the natural tendency of the muscles to recover their function. The muscle training is begun shortly after the pain and tenderness have subsided. All immobilization is discontinued for a few days

and the patient is encouraged to exercise his extremities in order to loosen up the joints and muscles which may be temporarily stiffened from the immobilization. Usually he is put in a tub of water once or twice a day and exercises his limbs under water. After a few days the effects of the immobilization have disappeared and it is possible to perform a satisfactory muscle examination and determine the severity and distribution of the paralysis.

The treatment is so planned that muscles which are paralyzed are made to contract by the patient's attempt to perform movements which are accomplished by these muscles. If he is not able to perform the prescribed movement the physical therapist moves the part passively through the full arc of motion of the involved joint while the patient, by concentration, endeavors to perform the movement. As the muscles become stronger the assistance is discontinued and the patient performs the movement with gravity eliminated, against gravity, and against resistance. The number of times a given movement is repeated varies with the power present in the muscles, but care is taken not to fatigue them by excessive exercise, because it has been shown that overuse of a weak or partially paralyzed muscle tends to cause loss instead of gain in power.

Before beginning the active exercise the muscles are first warmed by radiant heat and massaged gently. In performing the prescribed exercises mass movements, trick movements, and muscle substitution are avoided and the patient is taught to relax the opposing muscles, in addition any muscles which have become shortened are stretched passively and actively. During this period the activity of the patient varies inversely with the extent of the paralysis. The paralyzed muscles are protected by braces or splints and he is gotten out of bed as soon as the surgeon judges that this can be done without damage to the weak muscles. The stiffness of the neck and spine rarely always disappears spontaneously and rarely requires special treatment.

The muscle training is best carried out by a physical therapist, but if one is not available an intelligent layman can be taught

out the treatment in a fairly satisfactory manner. The muscles are tested every few weeks and not only is it noted whether or not a given muscle is able to contract, but its power is tested. The results of the muscle examinations are recorded and the progress of the patient can be determined by comparing the muscle chart with those made at previous examinations. When a given muscle approaches normal in power treatment of this muscle is discontinued. The muscle training is continued until the patient is approximately normal or until repeated muscle examinations fail to show further improvement in spite of adequate treatment. When this occurs the convalescent stage is ended and the patient enters the chronic stage of the disease and whatever paralysis is still present is considered permanent.

*The chronic stage.* The chronic stage begins when the convalescent stage ends that is, when there is no further hope of gain in power of the paralyzed muscles. Many partially paralyzed limbs contain muscles which are strong and which are opposed by weak muscles. In these limbs the muscle imbalance will tend to cause deformities over a period of years, and the same is true of the trunk. Some of these can be prevented by muscle transplantations or by stabilizing operations or by braces. The deformities which are most likely to occur are scoliosis, flexion deformities of the hips and flexion or hyperextension deformities of the knees and various deformities of the feet. In certain instances the patients are supplied with braces in order to enable them to use their paralyzed muscles more effectively. Likewise orthodox treatment endeavors to improve the function of severely paralyzed limbs by surgery and to rehabilitate these patients in order that they may carry on a normal life.

*The Kenny method.* The treatment is begun in the acute febrile stage of the disease ("as soon as the diagnosis of infantile paralysis is made") and apparently hot packs are applied to the extremities and trunk of the patient from the beginning. These packs are kept up continuously for a period of 12 hours a day. During the other 12 hours the patient is permitted to rest. The packs are renewed on an

average of once an hour but in some instances they are renewed every 15 minutes and in others the intervals are lengthened to 2 hours. The object of the hot packs is to alleviate spasm of muscles that is, the contracture of muscles which we believe is induced by the pain tenderness and hyperesthesia. It is also believed that they prevent or lessen the extent of the paralysis. The patient is kept flat in bed in the normal standing position with the feet supported by a board at the foot of the bed similar to that used in the early orthodox treatment.

In addition to the hot packs the joints are moved daily and the patient is taught to exercise his muscles and an attempt is made to re-educate the paralyzed muscles. This re-education is similar to the muscle training which is used in the orthodox method and has the same purpose in that it aims at the restoration of function in the paralyzed muscles. It differs in that it is begun in the acute stage of the disease and is continued through the stage of tenderness and contracture. It also differs in that no massage is used and attempts are made to stimulate individual muscles and the patient is made aware of the individual muscle that is to be exercised and taught its insertion and instructed to attempt to approximate the insertion to the origin of the muscle rather than to carry out a specific movement. I believe that the orthodox method is more natural and better because the brain pattern of muscle action is one of movement rather than one of action of a specific muscle.

The hot packs are continued as long as any muscle tenderness or any muscle spasm—that is, tightness or contracture of muscles—is present. Likewise the rest in bed in the normal standing position is continued during this period. The same is true of the muscle re-education. The schedule is rigid and emphasis is laid on the point that the patient must get the full treatment as directed otherwise he is not receiving the Kenny treatment.

Muscle examination and tests of muscle power are prohibited. Likewise no record is kept as to what muscles are paralyzed and what muscles are not paralyzed although in some instances records are kept as to what muscles are spastic and tender. All muscles

which are not able to contract are considered alienated. Those which are able to contract, no matter how feebly, are, as nearly as I can determine, considered normal. If a muscle which is being re-educated shows any ability to contract or to develop power it is considered that the mental alienation is cured and this muscle is from then on considered normal.

In the Kenny treatment no account is taken of spontaneous recovery, but all recovery is attributed to the method. Braces are prohibited and it is even claimed that the board at the foot of the bed is not a brace to prevent equinus of the foot, but that it is put there to stimulate the normal standing reflex. These patients are not permitted to sit up or walk nor are they gotten out of bed until muscle spasm has disappeared. Consequently, the paralytic cases are maintained flat in bed in the normal standing position month after month and treated with hot packs and muscle re-education. Contractures and early deformities are prevented by constant attention and frequent manipulation and stretching of the contracted muscles which have been relaxed by the application of hot packs. The efforts of the therapists are principally directed at relaxing the spastic muscles, preventing incoordination and, relieving mental alienation, that is, attempting to restore motor function to the paralyzed muscles.

The orthodox treatment is elastic and can be varied to suit the circumstances. What has been described is the standard orthodox treatment. The three principal variations are the under-water gymnasium of Lowman and the institute at Warm Springs, the prolonged protection of paralyzed muscles combined with intensive physical therapy, as practiced by the Kendalls in Baltimore, and what might be called the economical or common sense method.

It is this last which I use and which has proved to be satisfactory over a period of 15 years or more. The paralyzed limbs are immobilized during the stage of tenderness and contracture by splints which are removed daily for passive movements, or even by solid plaster casts in some instances. As soon as the tenderness and tendency to contracture have disappeared the casts or splints are re-

moved, the patient is permitted to move around in bed, is put in a tub of warm water daily and instructed to exercise and loosen up the joints which may have been stiffened somewhat by the immobilization.

At the end of a week or so after the initial stiffness has disappeared a muscle examination is made and the extent of the paralysis is determined. Then a plan of treatment is decided upon, and a member of the patient's family or a physical therapist is instructed as to what muscles to exercise and the patient is permitted to resume his normal activities as rapidly as he is able to do so, care being taken to protect the paralyzed muscles from being stretched or fatigued. These are protected by braces or by plaster molds if necessary. This so called home treatment is continued until there is no further improvement, when the patient enters the chronic stage and surgery is performed if indicated, or, if necessary, braces are prescribed for future use. It is believed that by this method few muscles which would ever have regained a useful degree of power are sacrificed and much expensive and arduous treatment is avoided.

From what has been said here it is evident that the Kenny treatment is wrong in theory, because it is based on the belief that the principal lesion of the disease is spastic contracture which is due to an acute inflammatory process in the muscles. This is treated by the constant application of hot packs accompanied by attempts at muscle re-education which are begun in the acute stage of the disease. The orthodox treatment recognizes that the principal lesion of the disease is in the anterior horn cells of the spinal cord and that the principal cause of crippling (if deformities be prevented) is the permanent weakening or complete flaccid paralysis of muscles whose anterior horn cells have been partially or completely destroyed. It prevents deformities, protects paralyzed muscles, and restores the maximum degree of power to all of the muscles of the body which retain some nerve supply. The rigidity disappears during the period of immobilization and rarely needs any other treatment. It is believed that the orthodox treatment is superior to the Kenny treatment for the following reasons:

1 Constant application of hot fomentations and attempts at muscle re-education in the febrile stage of the disease will tend to aggravate fatigue and disturb a patient who is sick with an acute infectious disease which is self-limited and any disturbance of such a patient may tend to weaken his resistance to the disease.

2 Refusal to use a respirator in the acute stage of the disease by the Kenny advocates may result in the death of certain patients with respiratory paralysis who could have been saved by a respirator.

3 There is no evidence that the Kenny treatment either prevents or decreases the extent of the paralysis.

4. Early active movement has been shown to prolong the stage of pain and contracture and tenderness in the muscles. Consequently I believe that patients treated by the Kenny treatment tend to remain in this stage of the disease longer than would the same patients if treated by the orthodox method of immobilization of the paralyzed extremities accompanied by daily movement of the joints through the nonpainful range.

5. Kenny patients who are paralyzed are made to remain in bed in the normal standing position for months. This cannot but result in prolonging the stiffness of the spine and tightness of the hamstring and quadriceps muscles.

6 The Kenny method of maintaining the patients flat in bed in the normal standing position until the spasm disappears causes paralyzed patients to be much more completely immobilized and for a much longer time than the same patients would be if they were treated by the orthodox method.

7 Immobilization of a limb which is tender and painful in a well fitting splint or cast relieves the pain, relieves the tendency to muscle contracture and prevents deformities much quicker and more easily than can be accomplished by the constant attention of a skilled therapist with the continuous application of hot packs for 12 hours a day. Those who deny this know little of the therapeutic value of rest.

8 Hot packs and warm baths are used by orthopedic surgeons occasionally for severe pain but only for short periods and only dur-

ing part of the day and then for a definite reason and not as a routine or during the acute febrile stage of the disease.

9. Early deformities may be prevented by either the Kenny or the orthodox method, but I believe that they can be prevented more easily and effectively by orthodox treatment.

10. Late deformities due to muscle imbalance especially scoliosis, calcaneus and flexion deformities of the hip may occur under either method. The denial that these late deformities will occur in patients treated by the Kenny method is based upon wishful thinking rather than upon the observation over a period of years of patients who have survived with muscle imbalance. The Kenny method has no treatment for these late deformities. The orthodox method treats them by surgery or by braces.

11 Trick movements and mass movements (inco-ordination) are treated more effectively by the orthodox muscle training than by the Kenny method.

12. The Kenny method advocates recognize paralysis as occurring very rarely in the disease and consider paralyzed muscles as alienated until they have failed to respond to treatment.

13 The orthodox method advocates recognize temporary (mental alienation) and partial paralysis and treat the patient accordingly.

14. The advocates of the Kenny method ignore the power present in a muscle but apparently believe that if a muscle can contract at all it is normal but merely partially alienated.

15 In the Kenny method muscle examination is forbidden and no records are kept of the condition of the muscles. Under orthodox treatment the muscles are examined regularly and the findings are recorded.

16 The principal effort of the Kenny treatment is directed toward relaxing the spastic muscles by very hot fomentations. Under orthodox treatment those muscles which are contracted are immobilized and prevented from shortening and tend to relax spontaneously as the pain and tenderness subside. It is for this reason that we have not emphasized this so called cardinal symptom which Miss Kenny claims to have discovered.

17 The very hot fomentations used in the Kenny method may cause burns and furuncles I have seen both

18 The orthodox method of muscle training is more natural and more effective than is the Kenny method of muscle re-education and in both systems the muscle training is directed at the relief of the same conditions, two of which Miss Kenny has renamed and claims to have discovered—mental alienation and inco-ordination

19 The Kenny treatment does not protect paralyzed muscles from being stretched Under orthodox treatment these muscles are protected with the hope that they may regain some of their power

20 I have seen paralyzed patients under the Kenny treatment who were maintained in the so called normal standing position for periods of 6 months and more In these patients there was marked stiffness of the back and hamstrings and quadriceps muscles were shortened Under the orthodox treatment I believe that these same patients would have had less stiffness and no more paralysis, if as much are buoyed up by extravagant promises of complete cure Many of these will have a rude awakening Under orthodox treatment care is taken not to promise the patient more than can be expected

21 In the Kenny treatment the patients are buoyed up by extravagant promises of complete cure Many of these will have a rude awakening Under orthodox treatment care is taken not to promise the patient more than can be expected

22 Many Kenny patients will be handicapped by lack of splints which would enable more effective use of their paralyzed limbs

23 All of the Kenny cures which I have seen were cures of nonparalytic patients who needed no treatment at all There is no evidence that these patients were ever paralyzed and under orthodox methods no time or money would have been wasted in showering treatment upon them when they did not need it

24 The advocates of the Kenny method do not recognize spontaneous recovery, but give credit to the method for all improvement which may occur in patients while under treatment and make extravagant claims of cures The orthodox method advocates recognize that the disease is self-limited and that most of the improvement which occurs is spontaneous rather than the direct result of treatment

25 The advocates of the orthodox method know that flaccid paralysis is the cause of crippling if deformity can be prevented Consequently, the treatment of the paralyzed muscles is of first importance in the orthodox treatment while it plays a minor rôle in the Kenny method

26 The Kenny method is expensive in material and man power, not only do the woolen blankets wear out after about a week's use and have to be replaced, but relatively large numbers of nurses and especially trained technicians are required to care for a given number of patients

27 The Kenny method demands that the prescribed routine be carried out with exactness It is very messy when many patients are present in a given hospital and requires special equipment and consequently it is not suitable in case of an epidemic The orthodox treatment, on the other hand, is elastic and can be given anywhere Poliomyelitis is an epidemic disease

28 Kenny propaganda in the lay press and over the radio has misled the public by the repeated statements that the Kenny method cures 80 per cent of the patients while under orthodox treatment "the average percentage of recoveries was 12 per cent" I cannot but believe that this is a deliberate misstatement of facts, because, while no statistics have been published, the 80 per cent cures claimed for the Kenny method are apparently based on the treatment of every patient in a given locality who had infantile paralysis and these percentages are compared with those of Dr McCarroll (5) who treated only patients who had residual paralysis of sufficient degree to cause them to come to the hospital for treatment, whereas, the large number of nonparalytic or temporarily paralyzed patients were not included in his statistics

There were 3 recent epidemics on this continent in which the orthodox treatment was used In Alberta in 1941 Dr Huckell (2) states that 82.2 per cent of 167 patients recovered under orthodox treatment to a stage where they were normal or practically normal Dr H Earle Conwell (1) states that 120 patients were personally followed by him in the Alabama epidemic in 1941 and 43



80 per cent of these 120 cases recovered under orthodox treatment to a degree where they were normal or practically normal. In the Baltimore epidemic of 1931 there were 296 cases of poliomyelitis. These were treated by the orthodox method and 9 died. Lenhard (4) examined the 289 survivors and found that 68 per cent of the patients had recovered and 14 per cent more had a slight residual paralysis, 11 per cent had moderate residual 5 per cent had marked residual and only 2 per cent were wheel-chair patients.

It is thus evident that the Kenny method does not even claim to cure any higher percentage of patients than the orthodox method has been shown to cure in 3 recent epidemics.

#### REFERENCES

1. CORNWELL, J. E. Personal communication.
2. MCCRELL, R. G. Annual Report of the Department of Health of the Province of Alberta, 1931.
3. JONES, R., and LOVETT, R. W. Orthopedic Surgery. New York: Wm. Wood & Co. 1930.
4. LENHARD, R. E. J Bone Surg. 1933, 3, 3.
5. MCCANNELL, H. R. J. Am. M. Ass. 1933, 107: 511.
6. POMER, J. F. J. Am. M. Ass. 1933, 107: 1438.

# NOVOCAIN INJECTION FOR MINOR INJURIES IN THE MILITARY SERVICE

FRANK C MURPHY, M D, Lieutenant, M C, A U S, and  
R W POSTLETHWAIT, M D, Captain, M C, A U S, Fort Myer, Virginia

THE mission of the Medical Department is to preserve the fighting strength of the United States Army. (8) To attain this objective, the injured soldier must be returned to his post, physically fit for duty, in the shortest possible time. In noncombatant zones, minor traumatism is the commonest cause of disability. A problem not existing in civilian practice is that of hospitalization of the patient until he is fit for strenuous activity. The patient in civil life who would be allowed to recuperate while carrying on at least part of his work must be admitted to the hospital in military practice. This added hospitalization not only increases the burden on medical personnel but decreases the effectiveness of the patient's unit while he is absent. Therefore, any treatment which is consistent with excellent medical therapeutics, and at the same time results in a shorter period of disability, is highly desirable. With this in view, we have discarded the usual conservative treatment for minor injuries and have adopted the recently accepted method of novocainization of the injured part, as suggested by Leriche.

During the year 1942, it was necessary to admit to the hospital 55 patients with acute strain or sprain of the knee, ankle, or back. The average duration of hospitalization for these patients was 10.3 days. Since novocain injection has been used for these injuries, we have admitted only 1 patient with severe traumatic synovitis of the knee for 48 hours. Two patients with acute exacerbation of chronic low back strain have required hospitalization. In no other knee or back and no acute ankle injuries have patients needed admission. It should be noted that very severe injury, with complete ligamentous rupture requiring prolonged immobilization and other treatment, is not considered in this discussion. This analysis is based on a series of novocain injections for 100 consecutive minor injuries seen at the Fort Myer Station Hospital during the past 5 months. Very minor strains and sprains are not included. In this series, ligamentous injury about the ankle joint was by far the most frequent, and the results of injection were most gratifying. Also included are injuries to the knee, shoulder, wrist, back, and miscellaneous injuries.

Novocain is a local anesthetic and as such its value is not questioned. William J Mayo wrote "I do not look forward to the day when regional anesthesia will wholly displace general anesthesia, but undoubtedly it will reach and hold a very high position in surgical practice" (5). Today, 15 years later, we can also foresee this same drug reaching its heights as a therapeutic agent. This means the young surgeon should and must become expert in its use. Novocain is the hydrochloride of para-aminobenzoyl-diethylaminoethanol. Labat states that the injection of this agent made in contact with a nerve, or in its proximate vicinity, results in a physicochemic combination with the nerve substance modifying its normal function and paralyzing the sensory nerve fibers. In the papers which we have reviewed, we have yet to find a satisfactory explanation for the mechanism which brings about the marked improvement in minor injuries following the injection of novocain. Based upon our observations of the symptoms and signs in these injuries, we believe the effect of novocain injection to be due to two principal factors, first, the immediate decrease of muscle spasm, and, second, the delayed but important correction of local anoxia.

In trauma, particularly in the region of a joint, the initial protective response is muscle

From the Surgical Service of the Station Hospital Fort Myer Virginia.

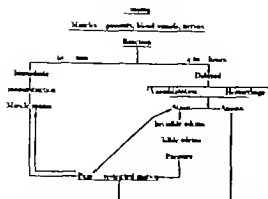


Chart 1. Diagram suggesting the pathologic physiology in injuries to muscles, ligaments, blood vessels and nerves.

spasm. This is demonstrated by the usual patient with a sprain of the ankle. The first symptoms are due primarily to restriction of joint motion rather than pain. At times severe pain is not present until several hours after the injury. This may be explained by the following sequence. As stated, the first response is muscle spasm manifested by stiffness and decrease in motion. During this period there is probably a transient vasoconstriction. As there is concomitant injury to the blood vessels and nerve fibers in the area, a vasodilatation then occurs. From the slowing of the blood stream in this area, the injury to the capillary walls, and the increased osmotic pressure (resulting from damaged tissue cells) first invisible edema and then obvious swelling of the part are noted.

With the clinically visible edema, there must also be swelling of the damaged nerve fibers vessel walls, and muscular and ligamentous fibers. This edema, combined with the stasis of the blood stream, results in anoxia of the involved tissues. This combination of factors i.e. the muscle spasm and anoxia, then results in a temporary vicious cycle with the muscle spasm and anoxia bringing about further tissue damage edema, and other untoward conditions.

To interrupt this cycle, two corrections must be made. This muscle spasm must be relaxed and the part must be adequately oxygenated. Novocain injected into the traumatized area performs these functions. By inhibiting the

painful impulses, the immediate result is diminished muscle spasm with resultant increase in mobility of the part. With the action of the novocain on the blood vessels and nerve fibers, there is a return of normal vascular tone bringing about improved circulation and better oxygenation. This improvement in the circulation and oxygenation plus the increased muscular activity leads to resorption of the edema fluid and extravasated blood, and a return to normal function.

#### TECHNIQUE

Before proceeding with the injection, all patients are examined clinically and roentgenologically. The patient is placed in the recumbent position as advised by Gorrell. This aids in preventing the occasional attack of syncope which occurred in about 10 per cent of our series. Although usually psychic in origin, the treatment itself is quite painful at times and this no doubt contributes to the side reaction. Pain appears to be most prominent when those areas which lie superficial as in the knee and wrist are injected. To allay apprehension the patient is reassured and the treatment explained, with emphasis on the freedom from pain which will follow shortly. The most tender points in the injured area are then identified with finger pressure. The point or points are marked with gentian violet and the skin prepared with tincture of merthiolate or iodine. Sterility must be scrupulously maintained for the danger of infection is ever present. A wheel is then raised with 1 per cent novocain at the points marked with gentian violet. A  $\frac{1}{8}$  inch 21 gauge needle is then introduced to the bone and a hematoma is searched for. If a hematoma can be found, and injected with the novocain an excellent result may be expected. When no hematoma can be located, the area in general is infiltrated. Immediately after the injection, the area is lightly massaged to aid in diffusion. Active motion of the part is then insisted upon. At first the patient is hesitant, but as he appreciates his freedom from pain, he quickly co-operates. The result is a relaxation of the surrounding muscles, relief of pain, and a rapid return of normal function. If the joint involved is a weight bearing or carrying joint,

# MURPHY ET AL NOVOCAIN INJECTION FOR MINOR INJURIES

an adhesive strapping or tight muslin bandage is applied. This acts as a pressure bandage to encourage the resorption of edema fluid, and also to protect the joint from further injury, as emphasized by Frankel.

## CASE REPORTS

**CASE 1** Private S, while working on the garbage wagon, was thrown to the ground when the wagon swayed sharply. He landed on his right foot, severely twisting the right ankle. He was able to walk only with the greatest difficulty. Examination showed marked edema about the ankle with four plus tenderness over the anterior talofibular and deltoid ligaments. X-ray examination was negative for bone injury. A tight strapping was placed about the ankle, and he was returned to his quarters. The following day, he reported at the clinic, complaining of more severe pain and marked limp on walking. Examination was essentially as before. The tender points over the anterior talofibular and deltoid ligaments were each injected with 5 cubic centimeters of 1 per cent novocain, a hematoma being encountered in the talofibular area. A Gibney boot was applied to the ankle. He obtained immediate and complete relief from pain and was able to walk bearing his full weight on the limb. On the next day, there was no pain or limp on walking. Five days after the injection, he reported to the clinic, having been on full duty which involved much walking the previous day, and had no complaints. The strapping was removed and the patient was discharged.

**CASE 2** Lt N, while running, turned the right ankle. This was followed by difficulty in walking and increasing pain. He was seen that evening by the officer of the day, who strapped the ankle and ordered bed rest. Ten days later, he was seen in the clinic, still complaining of marked pain in the ankle. Examination showed swelling about the lateral malleolus with four plus tenderness over the anterior talofibular ligament. Pain was severe on inversion of the foot. X-ray examination was negative. Five cubic centimeters of 1 per cent novocain was injected into the tender area and a Gibney boot applied. The immediate result was excellent. Forty-eight hours later, the patient was still free from pain, limp, and tenderness. At the next visit, the following day, he stated that his ankle felt normal and that he had played baseball on the previous afternoon. The strapping was removed and he had no further difficulty.

**CASE 3** Private K, while walking down hill during a training exercise, slipped and fell. The left leg slid backward, resulting in marked plantar flexion and inversion of the left foot. He complained of severe pain in the left ankle and could not bear weight. Examination showed four plus tenderness and marked edema over the lateral and anterior portions of the ankle. X-ray examination was negative. A needle was inserted down to the bone over the middle of the ankle, a hematoma was entered, and

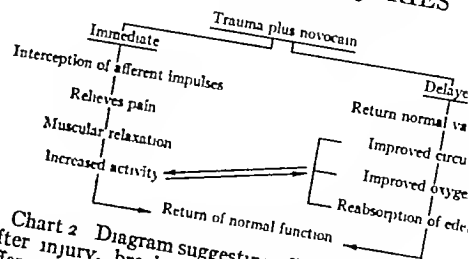


Chart 2 Diagram suggesting effect of novocain injection after injury, breaking vicious cycle by intercepting afferent impulses

5 cubic centimeters of blood was removed. 5 cubic centimeters of 1 per cent novocain was injected at this point and another 10 cubic centimeters in the talofibular ligament. The immediate result was relief of pain and marked increase in freedom of motion. The patient left the clinic walking without difficulty. He was followed for 10 days, and there was no recurrence of the pain or hemorrhage.

We have injected 41 ankle sprains to date. Involved in these injuries are practically every ligament about the joint. The most frequently injured are the ligaments on the external side of the ankle. In some cases several ligaments were traumatized and each had to be infiltrated. Of the 41 cases, 31 involved the anterior talofibular ligament either alone or in combination with the calcaneofibular, deltoid, calcaneocuboid or anterior annular ligaments. Six cases involved the deltoid ligament, either alone or in combination with the lateral calcaneofibular, or posterior talotibial. The calcaneofibular ligament was injured alone in 2 cases, and the external talocalcaneal in 2 cases. The majority of these cases can be classed as severe sprains with edema, ecchymosis, and such pain as to cause from partial to complete incapacitation. Twenty-four of these sprains were classified as severe, 12 as moderately severe, and 5 as mild. In at least 50 per cent of the cases, a hematoma was encountered. In the early part of the series, this fact was not recorded as its significance was not recognized, therefore, a definite figure cannot be given. The amount of novocain injected varied from 3 to 20 cubic centimeters, the average amount was 10 cubic centimeters. A modified Gibney boot was applied in 28 cases, a muslin bandage in 3, and no support was used in 10. Our best results were obtained in cases in which patients were treated within

12 hours after injury but good results were also noted in patients first seen 2 to 3 days following trauma and treatment with strapping and rest. The results in 73 per cent of the cases can be classified as excellent, with complete freedom from pain and full use of the ankle from the time of injection. Twenty four per cent had slight residual soreness and stiffness for several days but not enough to prevent the performance of active duty. About 5 per cent of these patients required a second injection. Two per cent continued to have pain and must be classified as poor. In the 2 latter groups the probability is that all the involved areas were not injected at the first treatment, for usually on the patient's return the tenderness was not found at the same point as that originally infiltrated. In the usual case patient received only one treatment, the amount of novocain injected into each area being 6 to 8 cubic centimeters. We have had no cases which showed separation of the inferior tibio-fibular joint as recently emphasized by Outland.

CASE 4. Private S during blackout, jumped from truck and felt sudden severe pain in his left knee when it was sharply twisted. He walked with marked limp and had pain on flexion and extension of the joint. Examination showed four plus tenderness over the lateral ligament at its fibular insertion. X-ray examination was negative for bone injury. The knee was trapped and heat applied for 4 days with no improvement. Ten cubic centimeters of 1 per cent novocain was then injected into the tender area of the ligament with resultant immediate and permanent relief.

CASE 5. Private M tated he was drilling and while running a double time, he accidentally twisted his right knee. This was followed by pain which was aggravated by exercise. After 4 days, there was no improvement and he reported to the hospital for treatment. Examination showed limitation of motion and three plus tenderness over the medial collateral ligament at the insertion into the tibial condyle. There was no excess fluid in the joint and an x-ray film was negative for bone injury. Treatment consisted in the infiltration of 8 cubic centimeters of 1 per cent novocain into and about the tender area. The immediate result was loss of pain and increased mobility. Recovery was uneventful.

CASE 6. Corporal P fell in the kitchen while attempting to catch a platter of steaks and struck his left knee on the floor. He entered the clinic 4 hours later with severe pain and stiffness in the knee joint. Examination showed obliteration of the normal contour of the joint by increase of synovial fluid. No

localized tender spot could be found, and there was no abnormal mobility of the joint. X-ray examination was negative for bone injury. Thirty cubic centimeters of viscid bloody fluid was aspirated from the joint and cubic centimeters of per cent novocain was injected. A pressure bandage as applied. He had no further pain and walked without difficulty. Two days later the bandage was removed and he was still able to walk without pain or limp. There was no reaccumulation of the excess joint fluid. Two weeks after injury joint appearance and function were normal.

Although injuries to the knee joint are not as frequent as those to the ankle in this clinic, we have used this treatment in 18 cases. The tibial collateral ligament was the site of the lesion in 11 cases, the fibular collateral ligament in 2, the quadriceps tendon in 3 and the patellar ligament in 1. There was 1 case of traumatic hemarthrosis thought to be due to synovial laceration. An average of 10 cubic centimeters of novocain was used in this group. Our results have been very encouraging although not as spectacular as in ankle injuries. This would be expected, as injuries of the knee are usually more serious than those of the ankle due principally to the structural differences in the two joints. Knee injuries frequently need more than one injection. It is not uncommon to find sprains of the medial collateral ligament injected and relieved, only to have the patient return 24 hours later complaining of pain in the quadriceps tendon where a tender point can be found just above the patella. Following the injection of this point, the patient usually makes an uneventful recovery. In cases in which two or three injections are unsuccessful, we are inclined to feel that the cartilage is damaged even though the history is atypical. If there is evidence of definite separation of the ligament, as demonstrated by marked abnormal mobility of the joint, the extremity is placed in a plaster cast following the injection. These however are not considered minor injuries. If excess synovial fluid is present, aspiration is performed. As demonstrated in Case 6 traumatic synovitis of the knee joint without localized tender areas responds rapidly to simple aspiration of the blood and injection of 10 cubic centimeters of 1 per cent novocain into the synovial sac.

CASE 7. Corporal H, while working on new barracks building, fell from the roof his abdomen

TABLE I—SUMMARY OF RESULTS

Site of injury	Excellent No.	Good No.	Poor No.
Injuries of the ankle	30	73	2
Injuries of the knee	7	38	8
Miscellaneous injuries	7	24	1
Injuries to lower back	2	16	6

striking a plant as he landed, causing acute flexion of the lower back. On entry to the clinic he complained of marked pain across the lumbar region. There was marked restriction of motion in the back. Spasm of both paravertebral muscle bundles was present. There was four plus tenderness over the left sacro-iliac joint and tenderness over the muscles at their lumbo-sacral origins. X-ray examination was negative for fracture. Fifteen cubic centimeters of 1 per cent novocain was injected into the tender areas of both paravertebral muscles. Pain was completely relieved and full flexion of the trunk was possible. The back was stripped. Patient had no recurrence except for slight soreness which lasted about 4 days.

It should be noted that our results in 4 cases of acute traumatic tenosynovitis have been 100 per cent unsatisfactory. 2 cases with involvement of the extensor tendons of the wrist, and 2 with injury to the Achilles tendon. As a result of this brief experience, we have discarded injection treatment in such cases, and now prefer splinting and physiotherapy.

Low back pain is becoming a serious problem in our clinic, particularly with the induction of older men. The treatment is tedious and the response is slow. We have injected some of these cases in an effort to hasten the recovery, but our results are unsatisfactory in 41 per cent of the patients treated. It is worthy of note that in the main, these unsatisfactory results occur in those who have had old back injuries with chronically recurring attacks of pain. All back injuries are roentgenographed for bony lesions before treatment, and the possibility of a herniated intervertebral disc is always considered. If either bone injury or herniated disc is the cause of the pain, good results from novocain injection cannot be expected. The use of the injection of novocain in these cases, however, though not of therapeutic value may be of diagnostic aid, as noted by Handman, Steindler, and Wolkin.

In patients with acute low back strain, seen early, without previous history of injury, results are more favorable. In 1 case of sciatic of undetermined origin, infiltration of the piriformis muscle as advocated by Haldeman and Soto Hall, relieved the symptoms.

CASE 8. Private B jumped from a truck, slipped and landed with his full weight on the extended right hand. Three days later he came to the clinic complaining of pain and swelling of the right wrist. Examination showed crepitation over the lower third of the extensor surface of the forearm on flexion and extension at the wrist. A diagnosis of traumatic tenosynovitis of the extensor tendons was made. Ten cubic centimeters of 1 per cent novocain was injected into the most tender area. The crepitus disappeared and the pain was immediately relieved. Next day the crepitus and pain had returned. A direct one was done but the results were no better. The patient was finally treated with splinting at the wrist and physiotherapy with a good result.

CASE 9. Private L was injured in a fight 7 months before he was seen at our clinic. From the time of injury, there had been pain in the left temporomandibular joint, and difficulty in adequately opening the mouth. Examination showed three plus tenderness over the region of the left temporomandibular ligament and moderate trismus. X-ray examination was negative for bone injury or subluxation. Two cubic centimeters of 1 per cent novocain was injected into the region of the temporomandibular ligament. Lower motor neurone paralysis of the zygomatic branch of the facial nerve developed but complete recovery ensued within an hour. The immediate results of the injection were the relief of pain and the ability to open the mouth readily and to a normal degree. Twenty-four hours later the patient had no recurrence of his disability except slight soreness in the region injected. One week later, he was asymptomatic and has remained so.

This case is presented as one occasionally sees a similar condition in which the routine treatment is difficult and usually unsuccessful, while the injection of novocain may bring about prompt amelioration of the symptoms.

A number of miscellaneous injuries were treated. There were injected with good results, 4 cases of shoulder and arm pain due to idiopathic myalgia as suggested by Travell, Rinzler and Herman. Five cases of sprain of the acromioclavicular joint without separation were injected with rapid recovery and with no immobilization. Five sprains involving the wrist were treated with good results. From 1 to 5 cases of the following conditions were injected all with good results: calcific bursitis, contusions of muscle, acute traumatic coccygodynia and sprain fracture of base of first metatarsal.

## SUMMARY

In attempting to shorten the period of disability caused by minor injuries the usual conservative treatment has been discarded in favor of novocainization of the injured part. The results and our experiences in the use of this drug in 100 consecutive minor injuries are presented. The physiopathology of minor trauma and the changes produced by the injection of novocain are discussed. Our technique is explained and x ray examination of the part before the institution of treatment is stressed.

The most commonly treated injuries and also the most responsive to the therapy were sprains of the ankle. No infections or toxic reactions resulted from the novocain injection. Rarely was more than the initial treatment with novocain necessary except in knee and back injuries. If favorable results are not obtained after 2 or 3 injections, further injection is not indicated. Typical case histories and a statistical study are presented.

## CONCLUSIONS

Novocain properly used for minor injuries is of definite value as a therapeutic agent. Novocain injection decreases the period of disability adds greatly to the comfort of the patient and permits an early return to normal activity.

## REFERENCES

- FRANKEL, E. L. *Lancet*, 930, 597.
- GORDON, R. L. *Clin. Med.* 64, 270.
- HAIDENHAIN, K. O. and SOTO-HALL, R. *J. Bone Surg.* 93B, 20675.
- HYNDMAN, O. R., STEINBERGER, A., and WOLFE, J. *J. Am. M. Ass.* 943, 200.
- LEE, J. GASTON. *Regional Anesthesia*, 2d ed. Philadelphia and London: W. B. Saunders Co., 1923.
- LEITCH, RICH. *The Surgery of Pain*. (Translated by Archibald Young.) Baltimore: Williams & Wilkins Co. 930.
- LEITCH, R., and ARTHUR, G. *Am. J. Surg.* 1934, 32-43.
- Military Medical Manual*, 4th ed. page 372. Harburg, Pa. The Military Service Publishing Co. 940.
- OUTLAND, TOM. *Am. J. Surg.* 943, 30324.
- TRAVELL, J. JOSEPH, S. and HENK, V. M. *J. Am. M. Ass.* 943, 2047.

# THE EFFECTS OF RAPID COMPRESSION WAVES ON ANIMALS SUBMERGED IN WATER

SAM L. CLARK, Ph D, M D, and JAMES W. WARD, Ph D, M D, Nashville, Tennessee

FOLLOWING the first World War Hooker (1924), reporting a series of careful investigations of the results of exposure of animals to the blast in air rifles and mortars, stated (p 219) "the exposure of animals anaesthetized or unanaesthetized to a sufficient air concussion leads to primary shock, i.e., a condition of low arterial blood pressure unassociated with hemorrhage and exposure." In the course of this investigation he observed the difference between the effects on animals of the blasts from the large rifles and of a series of high explosives which resulted from exposure to gun blast and did not simulate the shock condition. The use of high explosive was therefore abandoned.

With the greater use of high explosives in the present war, interest in these has increased and Zuckerman (1940) especially has made available knowledge of the effects produced on animals at different distances from given charges in air. He reported that in a certain zone about an explosion exposed animals suffered hemorrhage of pulmonary and abdominal viscera, hemorrhage of spinal nerve roots, and (at high pressures) of the pia and ventricles of the brain. Zuckerman showed that trauma to the lung on one side of an animal could be diminished by covering that side of the chest with a rubber cushion.

Williams (1942) described the effects of exploding depth charges on swimming animals, and discussed blast effects in warfare. The journal in which these experiments were published was "delayed by enemy action," and we did not see it until most of the present experiments were completed.

The pathological changes in Williams' animals were described by Cameron, Short and Wakely (1942). The chief findings were hemorrhage in lungs with rib markings evident, hemorrhages in the alimentary canal with occasional ones in epicardium, spleen, kidneys and ductless glands (the thymus of one animal and the adrenal of one). Interstitial emphysema was not uncommon. Hemorrhage was said to occur more frequently in the right lung than the left, the upper lobes and margins of the lung being the most common sites involved. Very little damage was produced in the soft structures of the body wall and the bones, and it was stated that there was no special tendency for the hollow, fluid containing viscera to be involved nor was the reproductive tract damaged. Some animals were killed at once and showed no marked pulmonary lesions. Perforations of the intestinal tract were not seen, though a dog directly over the depth charge had a ruptured stomach. There were areas of bruising and hemorrhage in the intestines which it was thought might have proceeded to ulceration and perforation if the animals had been allowed to live.

It has been stated that blast injuries in air occur predominantly in the thorax, while "immersion blast" injuries resulting from exposure to the detonation of high explosives underwater are chiefly abdominal (Breden, d'Abreu, and King, 1942). If the reports of experiments and cases of blast injury are carefully examined it will be seen that cerebral concussion, while often mentioned as a result of blast, actually appears less frequently than the pulmonary and abdominal trauma.

Experimenters have produced concussion in animals by blows to the head, an obviously effective method, and various explanations of the cause of the resulting disturbance of nervous function have been proposed, the most

From the Department of Anatomy, Vanderbilt School of Medicine.  
\*The work described in this paper was done under a contract recommended by the Committee on Medical Research between the Office of Scientific Research and Development and the Vanderbilt University.



recent one being a sudden acceleration or deceleration (Denny Brown and Russell) Mott (1916) suggested that with the compression of the chest by a blast in air cerebral concussion might be produced as a result of a wave of pressure traveling along the blood columns of arteries and veins which enter the cranium thus affecting the central nervous system. This theory has appealed to Stewart Russell and Cone (1941) and was supported by King and Curtis (1942) and others and it was with the idea of testing it that the present experiments were undertaken, though study of the other effects of immersion blast was also a major aim.

### METHODS<sup>1</sup>

In searching for a means of producing waves of compression about the body without the inconvenience of explosives, it seemed reasonable to set up waves in water surrounding the experimental animal. In order to produce compression waves in water an apparatus was constructed which was patterned after the following original experiment that Dr John Daniels, emeritus professor of physics at Vanderbilt University, was accustomed to demonstrate to his classes. In his demonstration an iron U tube was constructed with one end made of glass. It was filled with water, both ends were left open and in the end that was not glass a plunger was placed. The application of a sharp blow with a hammer to the plunger resulted in shattering the glass portion at the other end of the tube though the whole system was open to atmospheric pressure.

For the experiments reported here a U tube 28 inches high (Fig. 1) made of steel pipe 6 inches in diameter was set upright in a rack and filled with water or saline. A wooden plunger with a diameter approximately  $\frac{1}{2}$  inch less than the inside diameter of the tube made with a shoulder that would prevent the plunger from being driven entirely into the tube was placed in the water filled pipe so that it floated with its shoulder 1 centimeter above the top of the pipe. Above this end of the pipe two vertical steel wires were stretched to act as guides for a rack carrying a falling weight.

A tripping device allowed the rack to be released at any distance desired up to 5 meters above the plunger. Weights ranging from 425 grams to 7700 grams were used.

To operate the apparatus an animal was placed in the water in the open end of the U tube with the plunger floating in the other end. When ready a known weight was dropped onto the floating plunger from the height selected. As a rule animals were enclosed in a snugly fitting tubular cage of hardware cloth ( $\frac{1}{8}$  inch mesh) so that all could be placed in comparable positions. Such a cage facilitated the handling of the unanesthetized animals. With the apparatus experiments have been conducted on 152 rats, 31 mice and 8 cats. Of these 39 rats and all 8 cats were under nembutal anesthesia, the remaining rats and all mice were unanesthetized. Two mice were submerged in a can of glycerine which was suspended in the water filled pipe. Electroencephalograms (with records of heart rate and respiration) were taken on 8 rats and the 8 cats.

### RESULTS

When a weight of sufficient size was dropped from an adequate height animals were killed within a few minutes as the result of exposure to one impact. With lighter impacts animals survived the blow for longer periods or recovered completely. Immediately following a lethal impact the heart was quickly but temporarily slowed to half or less than half its original rate. Breathing was stopped for a period of a few seconds to more than a minute and respiratory movements if temporarily re-established were usually labored and apparently ineffectual for respiration and were finally accompanied by nose bleed. Early signs of the effects of the intra-alveolar pulmonary hemorrhage could be detected with a stethoscope. Failing respiration was accompanied by a falling heart. If the vagus nerves had been cut, respiratory movements continued after a blow without interruption (but with some slight slowing) until stopped by the death of the animal. After section of the vagi the heart rate was slowed at first only by about 10 per cent of its rate and then might

<sup>1</sup>The Division Underwood of the department of physics was most helpful in our experiments.

<sup>2</sup>The electroencephalographic apparatus used in these experiments was made available by grant from the John and Mary R. Markle Foundation.

speed up but become slower as the animal's lungs filled and death approached. Though an animal might run or walk normally just after the blow it soon became ataxic and incoordinate and died. Death usually occurred in 2 or 3 minutes, but was delayed in some animals for longer periods. Although occasional animals showed loss of corneal reflexes, ataxia and incoordination immediately after the blow, it was exceptional that any of these signs suggestive of direct and immediate involvement of the central nervous system occurred. They did, however, occur later as anoxemia followed the difficulties of respiration. Electroencephalograms have so far failed to confirm evidences of concussion at the time of the impact. The results of this and associated studies on the electroencephalogram in concussion will appear in another report.

Findings at autopsy were constant in animals dying shortly after an exposure to one impact, the most conspicuous being massive pulmonary hemorrhage. The lungs were as firm to the touch as liver and were deep red over most portions and throughout the lobes, though the apices were usually spared or were less hemorrhagic than the rest of the lungs, and if the hemorrhage was not maximal the bases were spared (Figs 2, 3, 4). It was exceptional to find blood in the pleural cavity. The animals evidently bled to death in their own lungs and as a result there was little blood on the systemic side of the circulation. The weight of the lungs at autopsy of animals with massive hemorrhage was four or five times that of a normal animal. Cutting the tissues of the body wall of such animals resulted in no bleeding, and the entire animal was pale. Even the abdominal viscera bled but little on cutting. There was no consistent engorgement of abdominal veins.

The intestinal tract, which was also the site of serious damage, showed scattered bruised, hemorrhagic areas in the cecum, colon, rectum, stomach, and small intestine. The cecum, lower ileum, and stomach were the regions most frequently affected but the number and severity of these lesions varied from animal to animal and were not as constant as the damage to lungs. In addition there were occasional punctate ruptures of the stomach or intes-

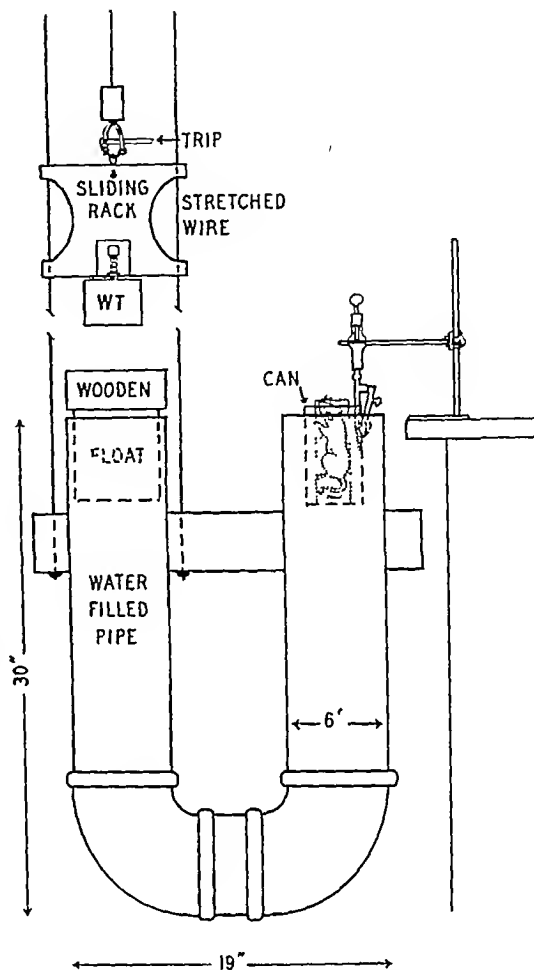


Fig 1 Diagram of the U pipe apparatus used in producing the impacts described in the text. The rat is represented as being in the wire meshed cage and thus in the water filled can. The weight was released automatically while being drawn up when the "trip" struck a rod set at the proper distance above the wooden float.

tines, allowing the escape of blood and intestinal contents into the peritoneal cavity. There was also in some animals hemorrhage into the lumen of the stomach and intestine without rupture of the serous coat.

The solid viscera, liver, spleen, and kidneys, very rarely showed damage and the bladder was not visibly injured whether it was more or less distended at the time of the blow. The reproductive system showed no gross lesions and neither the pregnant uterus nor its contents in one animal was visibly damaged.

The brains and spinal cords showed no evidence of gross hemorrhage or damage. Sections of these structures are being prepared for study. The muscles, body walls, and skeletal framework were apparently uninjured.

Although there was no large amount of water surging in the pipe at the time of the impact, it was thought possible that this might play a part in the injury. To avoid the effects of such surges a tin can open at the top was almost filled with water and suspended by a clamp in the end of the U pipe so that its water level was about the same as the water level in the pipe surrounding it (Fig. 1). The experimental animals were then placed in the water in the can, and were thus protected from large movement of water in the pipe. The effects upon the animals were similar to those placed directly in the pipe, although the can appeared to give a slight protection from the effects of a given impact.

After the first few experiments were performed it was observed that the effects were not always the same on successive animals with the same impact (same weight and height of fall). By repeated testing the following were found to affect the results of impact:

- 1 The size of the falling weight. The greater the weight from a given height, the greater the damage to animals of the same size (Figs. 3 and 4).

- 2 The height the falling weight dropped. The greater the height a given weight dropped the greater the damage to animals of the same size (Figs. 2 and 3).

- 3 Size of the animal. The larger the animal the less the effect for a given impact. A weight (4350 gm.) that caused the death of a 20 gram mouse when falling 40 centimeters had to fall 15 meters to kill a 300 gram rat, and 4.5 to 5 meters to kill a 2 kilogram cat. A weight (1800 gm.) dropping 25 meters killed a rat weighing 175 grams but had to fall 5 meters to kill a rat weighing 360 grams.

- 4 Position of the animal. If an animal was allowed to hunch itself up in the water as a rat does in swimming it was not as seriously affected as if it was stretched out in its wire cage with all sides equally exposed.

- 5 Amount of submersion. Only that part of the animal below the water level at the

time of the impact showed the typical lesions. For example if the animal's caudal end was immersed up as far as the diaphragm, the typical abdominal trauma resulted, but the lungs were spared. If the animal was immersed to the middle of the thorax, the upper part of the lungs were spared when an impact was applied that was lethal to the fully immersed animal. It is of significance that such incompletely immersed animals did not die immediately from the blow if a sufficient amount of the lung escaped trauma and hemorrhage.

- 6 The state of inflation of the lungs. Damage was greater to fully inflated lungs than to deflated lungs. An animal's life could be saved by holding its lungs in a state of deflation with the aid of an intratracheal cannula at the time of an otherwise lethal impact.

- 7 The presence of protective coverings. Wrapping a rat in a cork life preserver (3 mm. in thickness) or a sponge rubber one (5 mm. thick) resulted in saving the regions covered from much of the effect of an otherwise fatal blow.

- 8 The presence of air in viscera or tissues predisposed to damage in that area. For example after injecting air subcutaneously and allowing it to spread about in small bubbles, exposure of the animal to immersion impact resulted in hemorrhage in the region of subcutaneous emphysema and not in other subcutaneous areas. When by laparotomy a segment of intestine was tied off and filled with air it showed marked bruising and hemorrhage after an impact to the animal while neighboring collapsed segments of gut were spared. The presence of isolated gas bubbles in the intestine was apparently the explanation for the localization of damage. When rupture of the gut had occurred gas bubbles in the peritoneal cavity have been observed at autopsy.

Since evidence of cerebral concussion was rare in these experiments a few attempts were made to produce it by immersing a part or all of the head of the animal in the water at the time of a blow. Concussion was not produced by blows within the limit of the apparatus upon the intact head of rats or cats or upon two cats with a half square centimeter of the calvarium removed (in one over the vertex of the cerebrum and in one over the cerebellum).

with that part of the head submerged. However, the heart was markedly slowed following an impact in the cat with the exposed cerebellum. With tracheal cannula in place it was possible to submerge the head of an anesthetized animal. An intact animal could be quickly ducked head down in the pipe long enough for the impact to be applied. Bleeding of the nasal mucosa and swelling sufficient to make breathing difficult followed such a procedure in rats, but concussion did not result.

#### OBSERVATIONS AND COMMENT

The method used in these experiments of producing a wave of compression in water surrounding an animal has certain obvious advantages over the use of explosives. It is possible to control the magnitude of the impact, and to measure its wave form. The animal can be completely or partially subjected to the effects of an impact which can be graded so that it produces little to maximal damage. Recording of electroencephalograms and electrocardiograms is possible during an experiment, and, of even more significance, the animal and its reactions can be observed at all times, even at the moment of impact.

While Hooker and Zuckerman were able to observe the immediate effects on animals of blast in air, most of the observations on people subjected to immersion blast have been made hours after the experience, though the testimony of those affected has aided in filling in the early part of the story. There was also a lapse of time in the experiments described by Williams between the setting off of the depth charges and the collection and observation of the exposed animals.

The pathological effects of the impact in these experiments, are so similar to those produced by high explosives in air and to those observed following immersion blast as described in the literature (Cameron, Short, and Wakely) that little description is necessary. Recent reviews of literature have been given in the article by Zuckerman, King and Curtis, and Williams.

Physically the impact obtained from dropping the weight on the floating plunger sets up waves in water having characteristics similar to those produced by setting off an explosive

under water. Both produce primary "compression" waves of extremely short duration. Preliminary measurements by means of piezocrystal and cathode-ray tube with our apparatus indicate that the wave, like that about a discharge of high explosive in air, occurs in about  $1/5000$  of a second (exact measurements are yet to be done). It presumably travels at the speed of sound in water (5657 ft per sec at  $60^{\circ}\text{C}$ , 4714 ft per sec at  $15^{\circ}\text{C}$ ). Williams brings out in his discussion of blast (p. 42) that, "the pressure wave in water travels at the same speed as it does first in air, i.e., 5000 feet per second, and it should be noted that this is the same as the speed of sound in water." The surge of water produced by the expansion of gases about an explosive is absent with our apparatus.

That the effect on the animals in these experiments is not due to a slow surge of any large amount of water is indicated by the experiments in which the animal was placed in water in a metal can and this in the pipe. No surge of water was possible with this arrangement yet the effects were the same except for a slight diminution of the effect on the animals in the can. A rapid wave of compression (water and metal being relatively incompressible) however could travel through such a system readily. It may be that the reflection of the wave in the pipe used produced a slightly different situation from that in open water. However, an interesting commentary on this phase of the experiments was given us by Dr. H. C. Francis who stated that as a boy he had "stunned" fish by hitting exposed rocks along streams with a hammer. Another acquaintance told us of killing fish in an ice covered stream by dropping rocks on the thick ice, not breaking the ice but killing the fish which floated to the surface at a nearby unfrozen rapid. Fish killed at sea near depth charge explosions show little or no pathology (Breden, d'Abreu, and King).

In these experiments if an animal did not die from a given impact in a few minutes, its chances of survival were greatly increased. If the lungs were not damaged sufficiently to prevent successful respiration the animal would survive to take its chances with the delayed results of shock from blood loss, or





Fig 2 Bases (left) and dorsal aspect (right) of lungs of an unanesthetized rat subjected to an impact while submerged to the neck in water. Rat weighed 180 grams, falling weight 1800 grams, height of fall, 3 meters. Scattered small hemorrhages visible on bases. More marked hemorrhage on dorsal midportion of lungs. The animal survived but was killed 30 minutes after the impact was applied.



Fig 3 Bases (left) and dorsal aspect (right) of lungs of an unanesthetized rat subjected to an impact while submerged to neck. Rat weighed 180 grams, falling weight, 1800 grams, height of fall, 4 meters. Note the greater hemorrhage on both surfaces as compared with Figure 2. The apices were spared but are not shown in the picture. Note also sparing of the lower margins posteriorly. The animal bled at the nose but did not die immediately. It was killed 10 minutes after the blow.

in water was noted also in the recent symposium in the *Naval Medical Bulletin*.

The experiments by Williams (1942) on animals in the sea in the neighborhood of depth charges gave results strikingly similar to the ones reported here. An interesting difference in results, however, is worth notice. In the case of 2 of Williams' dogs exposed to the blast, 1 was protected by a rubber jacket over its abdomen, the other by a similar jacket over its chest. The damage to the lungs was de-

scribed and pictured as greater in the animal with its *chest* covered than in the one with its *abdomen* covered. The explanation suggested was that the pressure via abdomen and diaphragm was effectively greater than that through the chest wall. It seems likely from our experiments that since these dogs were swimming some differences in posture or the effectiveness of the covering, or in the stage of respiration, or in the content of gas in the intestinal tracts at the time of the explosion



Fig. 4. Basal (left) and dorsal (right) views of lungs of an anesthetized rat subjected to an impact. His submerged to the neck. Rat weighed 40 grams, falling eight, 4350 grams, height of fall, 4 meters. Observe the greater hemorrhage from the fall of heavier eight. Note the sparing of the midportion of the base and that more hemorrhage occurred in the right lung than in the left. The animal died 1 minute after the impact.

was the explanation of the apparent reversal of the expected result. That pressure from the abdomen on the lungs is not as significant a cause of lung damage as the lateral pressure on the thorax is indicated by the fact that the portion of the lungs in the rat over the middle of the diaphragm (especially the apical lobe of the right lung) was commonly fairly free of damage after a lethal blow. This is further supported by the results of partial submersion where the damage appeared only in those parts near or below the water level. Cameron, Short, and Wakely noted in Williams' animals that severe hemorrhage was much more frequent in the right lung than in the left, an observation which was often true in submersional pulmonary hemorrhage in our rats. The explanation for this is not obvious.

That cerebral concussion was not the common result of these experiments is interesting. Perhaps greater impacts might have produced concussion regularly, but since animals died within a few minutes from pulmonary hemorrhage with the impacts used, the problem of the influence of cerebral concussion becomes of minor importance in terms of survival.

The instantaneous deaths of people subjected to blast may be as suggested by Mott, the result of a suddenly applied compressive wave that is transmitted by way of the tissues to the cerebrospinal fluid and central nervous system

resulting in instantaneous arrest of the function of the cardiac and respiratory centers. Williams and his associates had some animals killed without marked pulmonary hemorrhage and these may have been instantaneous deaths. Under such conditions the trauma to the lungs may have been present but the sudden stoppage of blood flow and respiratory movements could have been the reason for the small amount of hemorrhage. Denny Brown and Russell (1940) state that concussion is potentially fatal without macroscopic lesions of the brain stem. Hooker, from observations on animals in his experiments not immediately killed, states that whatever injury to the nervous system was caused by air concussion it did not destroy the functional activity of medullary centers. He observed that sight and hearing were present in the anesthetized animals after exposure and in all animals the respiration continued, while in the anesthetized ones the corneal reflex was very active until just before death. He pointed out, however, that these observations do not exclude a functional disturbance in the medullary centers, especially those dealing with heart rate and vascular tone.

Hamlin (1943) discussed the neurological observations on the patients considered in the *Army Bulletin* symposium rescued after exposure to immersion blast. He suggested that a

blast wave of sufficient magnitude may be transmitted to the spinal canal and then to the cranial cavity, setting up a force through the spinal fluid, and possibly the central nervous system itself, which might be analogous to the phenomenon of cerebral acceleration that follows a solid blow to the head. He states, however, that the brief unconsciousness after immersion blast which occurred in many of his patients was probably more often caused by a rapid shift in the vascular reservoirs of the great vessels producing transient ischemia of the brain rather than concussion. Effects from compressive waves of longer duration may result in neurological symptoms even if the more rapid ones do not. The case of crushing and compression of the chest described by King and Curtis was of the sort allowing time for transmission of fluid pressure to the cranial cavity.

Recognition of concussion is not always easy. Clinically it is described simply as loss of consciousness following trauma, with recovery and no accompanying pathology. Experimentally since the state of consciousness in an anesthetized animal is an impossible criterion other standards must be set. Denny-Brown and Russell (1941) have described concussion produced by blows on the head as an immediate but transitory paralysis of all bulbar reflex mechanisms they examined, accompanied by an original "start reflex," bradycardia with a respiratory pause, and fall in blood pressure, various motor effects, and a transient rise in blood pressure. The last is said to be related to the phase of traumatic paralysis and may obscure the fall in blood pressure just mentioned. It has been observed in the present experiments that the heart rate markedly slows immediately following a heavy impact, though it may increase with a light one. Only slight slowing of the heart occurs if the vagus nerves have been previously cut. The respiration is inhibited at the time of a heavy impact unless the vagus nerves have been severed. After an interval (a few seconds to more than a minute) respiratory movements begin again, and the animal may survive. Efficiency of respiration and survival seem to be correlated with the amount of pulmonary hemorrhage.

The effect of previous sectioning of the vagus nerves on the cardiac and respiratory rates after the impact suggests that the variations in these rates may be due to afferent impulses over the vagus nerves rather than concussion of the central nervous system. The mild slowing of the heart that occurs after section of the vagi could be due to the effects of the alteration in the filling of various heart chambers and vascular channels secondary to the changes in blood flow through the traumatized lungs. Inhibition of accelerator nerves to the heart may be involved.

While some of the phenomena of concussion have been observed in our experiments at the time of the impact, especially the respiratory disturbance and slowing of the heart, the unanesthetized animals which had received a lethal blow were obviously not suffering from concussion in the first minute or so afterward. It is true the animals later showed loss of awareness and of reflexes, but this was apparently associated with the marked respiratory distress and internal hemorrhage. As death approached, the color faded from the eyes and exposed mucous membranes of the rats, while the gasping respiratory movements were obviously ineffectual.

The influence of air in lungs and hollow viscera, and in subcutaneous regions (previously injected) is apparent from the account of the experiments. In this connection Williams states from observations on animals in water near depth charges (p. 42) "When the pressure wave impinges on the body there will be no reflection, but the pulse will be transmitted through the tissues without displacement, just as if the body were so much water. However, when the transmitted pulse encounters an air cavity in the body, e.g., the lung, the static wave of pressure will change into a wave of kinetic energy in the layers of tissue lining that cavity and a disruptive effect will occur."

The absence of damage in various body tissues, the brain, the solid viscera, and the water filled bladder of our animals is thus understandable. The amount of pressure necessary to cause disruption of tissue with air on one side of it is obviously not sufficient to injure seriously tissues which may be considered as completely permeated with water.



Our animals did not lose reflexes in the areas exposed to impact so even the peripheral nerves and endings must be able to withstand these pressures. That concussion of peripheral nerve fibers is possible with an air blast was shown by Krebs, Schoepfle and Erlanger (1942). Perhaps the animals and people who have suffered instantaneous death were subjected to much higher impacts. It is of course known that the application of local blows to the body have resulted in sudden death without demonstrable pathology but other causes than concussion may apply here. Perhaps cerebral concussion is more likely to be seen when the head is exposed to an excessive blast from which the body is so protected that pulmonary hemorrhage is avoided. Concussion which follows a blow to the head from a flying object or from the individual's head striking something solid as the result of a blast is a different matter. Scott (1940) has recorded sudden increase of intracranial pressure to heights above systolic blood pressure in dogs when unconsciousness followed a blow to the head.

In man the effects of nonlethal blasts on the nervous system have been stressed as contributing to the various neuroses of war (Mott, 1916; Carver, 1919). Russell (1942) states that in civilian cases the incidence of post concussional symptoms is lower than generally realized and the duration of disability surprisingly short. It was true in our experiments that animals exposed to impacts which were not fatal in the first few hours tended to recover rapidly.

#### SUMMARY AND CONCLUSIONS

1. A method is described for subjecting animals to shock waves in water by dropping a weight on a floating plunger. The method allows continuous observation of animals throughout the experiment. Submerged ani-

mals exposed to an adequate impact in the apparatus died within a few minutes.

2. The effects of the impacts produced in these experiments were similar to those described in the literature as resulting in nearby animals and man from the detonation of explosives in water and in air.

3. Pulmonary damage with marked hemorrhage into the lungs was the cause of immediate death in the animals in these experiments.

4. Abdominal injury was largely confined to the gas-containing portions of hollow organs, with hemorrhage in the walls and lumina and occasional perforation.

5. The following factors modified the results: size of the falling weight and the height it dropped; size and position of the animal; the amount of submersion; the state of inflation of the lungs; the quantity and position of protective coverings; the presence of air in viscera or tissues.

6. Cerebral concussion was not the common result from the impacts used in these experiments. The animals died of other causes.

#### REFERENCES

- BREEDY, V. P., D'ARNEY, L. L., and KING, D. P. *Brit. M. J.* 94, 44-46.
- CAMERON, D. R., SCOTT, R. H. D. and WALKER, C. P. G. *Brit. J. Surg.* 94, 30, 40-44.
- CARVER, ALFRED. *Brain*, 9 4, 3-120.
- DUFFY-BROWN, D., and RUSSELL, W. *Lancet*, *J. Physiol. Lond.* 94, 99, 33.
- Ibid.* 94, 99, 6P-7P.
- HAMILTON, H. L. U. S. *Nav. M. Bull.* 94, 4, 26-3.
- HOOVER, D. R. *Am. J. Physiol.*, 94, 67, 9-274.
- KING, JAMES D. and CARTER, G. M. *Surg. Gyn. Obst.* 94, 74, 33-62.
- KREBS, A. D., SCHOEPFLE, G. M., and ERLANGER, J. *Proc. Soc. Exp. Biol. N. Y.* 94, 49, 73-75.
- MOTT, FRANK W. *Lancet, Lond.*, 9 6, 33, 334.
- PALMER, JOSEPH, and ULDALL, J. *J. U. S. N. M. Bull.* 94, 4, 3-8.
- RUSSELL, W. *Lancet*, *Brit. M. J.* 94, 3, 371.
- SCOTT, W. W. *Arch. Nerv. Psychiat.*, 94, 43, 370-383.
- STEWART, O. W., RUSSELL, C. K. and COVEY, W. *Lancet, Lond.* 94, 7.
- WILLIAMS, E. R. P. *Brit. J. Surg.* 94, 20, 35-49.
- ZUCKERMAN, N. *S. Lancet, Lond.* 94, 9-14.

# OSTEOGENIC SARCOMA

## I A Modified Nomenclature and a Review of 118 Five Year Cures

IAN MACDONALD, M D , and JOHN W BUDD, M D , Lieutenant Commander, M C , U S N R ,  
Los Angeles, California

THE organization in 1921 of the Registry of Bone Sarcoma, by the late Dr Ernest Amory Codman, was the beginning of a co-operative group effort in the study of a complex group of neoplasms. There was extant a large mass of information, clinical and pathological, concerning bone sarcoma but the individual blocks of knowledge failed to fall into place largely because there existed no accepted "blueprint" of nomenclature, no established concepts as to the histogenesis and natural history of tumors of bone. Organized under the aegis of the American College of Surgeons and maintained as a research problem by that organization since 1922, there are now some 2,400 cases in the Registry. The signal achievement of the Registry has been in the review and analysis of pertinent material from this large number of bone tumors by a committee composed largely of pathologists and surgical pathologists, a method of attack which has now been emulated in the study and clarification of other groups of neoplasms. The success which has attended this co-operative effort is aptly illustrated by the contrast between the nomenclature of bone tumors first adopted in 1923 and the last revision published for the committee by Ewing in 1939, parts of which are shown respectively in Tables I and II. Some sort of order has thus been brought out of terminological chaos as the criteria of different bone tumors have been recognized and their histogenesis to some extent established.

The whole field of tumors of bone nevertheless still offers many unexplored areas, and ideas concerning sarcomas of bone are considerably more fluid than in most other divisions of oncology. Ferguson, for example, recently has questioned even so established a principle as early amputation. The Registry material

constitutes an orderly, documented mass of information of unparalleled value in the investigation of bone sarcoma. This study is based on material from this source, and is confined to those malignant tumors arising in the connective tissue elements of bone, the "osteogenic" sarcomas.

The revised classification of 1939 placed the bone tumors of connective tissue origin into two groups, the osteogenic series and the chondroma series. The osteogenic series as classified by Ewing included those neoplasms that form bone as well as those which histologically were strictly fibrosarcoma, while the chondroma series had been split off from the general group of osteogenic sarcoma as a separate entity. In 1941 the Registry of Bone Sarcoma reported 1,022 registered cases of "osteogenic" sarcoma. Of this number 654 had been treated 5 years or more prior to 1941 and only 97, or 14.8 per cent, were accepted as five year cures. One hundred fifteen instances of chondrosarcoma, with 21 five year cures (11 per cent) had been found in the material, with other examples of chondrosarcoma undoubtedly remaining unidentified without a complete survey of the entire collection.

This group of 118 five year cures of a highly lethal type of neoplasm offered a challenge to a critical review of their clinical and microscopic features and of the therapeutic methods by which they had been treated. It was anticipated that differences might be found in a comparison of the cases of patients cured with an equal series of cases of uncured patients to be unselected except for comparable regional incidence. Through the co-operation of the Registry it has been possible to study the case histories, roentgenograms, and microscopic slides of the entire cured group, but the present emergency has interrupted the study with only 47 fatal cases reviewed.

From the University of Southern California School of Medicine

TABLE I.—CLASSIFICATION (1923) OF BONE SARCOMA REGISTRY (OSTEOGENIC TUMORS)

1. Periosteal fibrosarcoma
2. Osteogenic tumors
  - a. Benign
    1. Eosinoids
    2. Osteoma
    3. Chondroma
    4. Fibroma
  - b. Malignant
    1. Anatomic types
      - a. Medullary and subperiosteal
      - b. Periosteal
      - c. Sclerosing
      - d. Telangiectatic
    2. Undifferentiated sarcoma

TABLE II.—CLASSIFICATION (1939) OF BONE SARCOMA REGISTRY (OSTEOGENIC TUMORS)

1. Osteogenic series	Malignant	
	Medullary and subperiosteal	Benign
Osteogenic sarcoma	Telangiectatic	Eosinoids
		Osteoma
	2. Sclerosing	
	3. Periosteal	
	4. Fibrosarcoma	
	(a) Medullary	
	(b) Periosteal	
	5. Periosteal, capsula	
Chondroma series	Chondrosarcoma	Chondroma
	6. Myxosarcoma	

During the review of the 118 cases of cures it became evident that few of these tumors presented the microscopic criteria of bone producing sarcomas. Thirty seven (31 per cent) are tumors characterized by a spindle cell morphology with a fibroblastic type of stroma. Fifty six (46 per cent) in our opinion belong to the newly created chondroma series and only 14 (12 per cent) can be called true bone producing sarcomas. In only 4 instances the tumor shows sufficient differentiation toward more than one type of tissue to justify compound names. Six cases studied are regarded as not belonging in this series of tumors.

These findings are in sharp contrast to those of the uncured group. As far as the analysis had been carried only 15 per cent of the latter group have a fibroblastic structure while cartilage and bone forming properties are found with equal frequency in the remaining 85 per cent.

Since the histological structure observed in the majority of sections studied seems to consist predominantly of one of the three fundamental types of connective tissues this offers the most logical basis for a classification of the primary malignant tumors of osseous tissue. More than a decade ago Phemister outlined clinical, roentgenographic, and histological criteria of cartilaginous tumors sufficiently distinctive to merit the recognition of chondrosarcoma as a special type of bone tumor. We propose to ascribe clinical and microscopic features and a numerical importance to fibroblastic tumors which should justify their inclusion as a group of neoplasms comparable in significance to the chondroblastic tumors.

There is need for a specific term for the designation of the third or bone producing member of the triad of connective tissue tumors arising in bone since the term osteogenic is properly interpreted as implying only originating in bone and not specifically forming bone. For this purpose the term osteosarcoma formerly employed by Mallory, Ewing and others seems inescapable.

Based on these considerations, the following modified classification of malignant connective tissue tumors of bone is therefore proposed with their benign counterparts included.

Osteogenic series	Malignant		Osteogenic sarcoma	Benign
	a. Osteosarcoma	b. Chondrosarcoma		
		Fibrosarcoma		Chondroma

The designation of subvarieties of osteosarcoma based on pathological anatomy appearing in Table II may be listed under (a) but this primary division adheres more rigidly to a pattern of histogenesis.

The term osteosarcoma is used here to include only those neoplasms in which an osteomucoid matrix is being formed. A fibrillar or mucoid substance may be evident in many areas but a search of well preserved and viable areas of tumor reveal anastomosing trabeculae of a dense homogeneous, formed stroma which trap the adjacent cells in the ground substance.

Chondrosarcoma includes the group of neoplasms characterized by a firm hyaline stroma. The cell morphology is highly variable but usually is round or oval where the matrix is solid. In the frequent areas of mucoid change stellate and spindle forms are usually observed. Intercellular substance may be

TABLE III—RELATIVE INCIDENCE OF TYPES OF OSTEOGENIC SARCOMA

	5 year cures		Uncured	
	No	%	No	%
Osteosarcoma	14	11.8	19	40
Chondrosarcoma	56	47.5	19	40
Fibrosarcoma	37	31.4	7	15
Complex sarcomas	4		1	
Not diagnosed	1		1	
Nonosteogenic	6			
Total	118		47	

noted only in islands in which the cells are more or less evenly distributed through a glassy matrix. There is a marked tendency toward calcification and in some tumors, due to necrosis, only the calcium deposits remain in large areas of the tumor.

The osseous fibrosarcomas are fundamentally similar to fibrosarcoma primary elsewhere in the body. They are characterized by a stellate or spindle cell morphology with wavy bundles of collagen fibers criss-crossed or intertwined. Retrograde changes are very prominent with hyalinization, mucoid degeneration, and calcification of frequent occurrence. Secondary bone formation is to be found in hyalinized or calcified stroma, and occasionally sufficient osteogenesis is encountered to justify the diagnosis of ossifying fibrosarcoma. This feature is observed as frequently in fibrosarcomas of soft tissue as in those of osseous origin. In practically all of the fibrosarcomas studied the evidence offered by roentgenograms and gross anatomical descriptions is such as clearly to indicate their origin in bone. Thus they are not related to the spurious pretenders to osteogenic status, parosteal and capsular sarcomas, nor were any of them associated with neurofibrosarcomatosis. In one instance fibrosarcoma had developed in Paget's disease. Some of these tumors seem to have been medullary in origin, others periosteal, but we believe that many also originate in cortical bone.

In rapidly growing bone sarcoma the cells may be so immature that no connective tissue is observed, and the tumor is therefore indifferent. In the majority of cases, however,

TABLE IV—CLINICAL FEATURES IN 3 TYPES OF OSTEOGENIC SARCOMA

	Osteosarcoma		Chondrosarcoma		Fibrosarcoma	
	5 yr	Un cured	5 yr	Un cured	5 yr	Un cured
Average elapsed time in months from onset to amputation	11.4	6.0	8.6	9.0	18.0	11.0
% in which biopsy done	50	31	59.4	52	64.8	*
% irradiated	42	52	46	52	56.7	*
% in which tendency to encapsulation observed	33	0	57.0	0	73	*

\*Inadequate material

sufficient evidence of functional differentiation can be found to warrant classification in one of the three groups. The functional differentiation is usually predominantly of one type, and in only a small percentage of the tumors is a diagnosis of a mixed pattern deemed necessary. Some of the more anaplastic chondrosarcomas in which cartilage is lacking offer considerable difficulty, and are recognized by the unusual epithelioid or polyhedral cell morphology mentioned by Ewing.

The relative frequency of the three forms of osteogenic sarcoma is summarized in Table III. The incidence of osteosarcoma and of fibrosarcoma in the cured and uncured groups is so inversely proportional as to confirm the known extraordinary degree of malignancy of true bone producing sarcomas (osteosarcoma). Although chondrosarcomas account for the largest single number of cured cases, they occur in equal incidence with osteosarcoma in the smaller series of uncured patients. As the extreme variation in microscopic structure would suggest, chondrosarcomas may range from a well differentiated tumor of debatable malignancy to a highly anaplastic, osteolyzing neoplasm. Fibrosarcoma is the least malignant member of the triad, a tumor of slow or even indolent growth generally late in its metastases. Some of them resemble certain fibrosarcomas of soft tissues in this latter respect.

The amount of matrix formed by any of the three tumors seems unimportant as a prognostic feature. The ability of the host to accomplish some degree of encapsulation of an osteogenic sarcoma must be regarded as a most

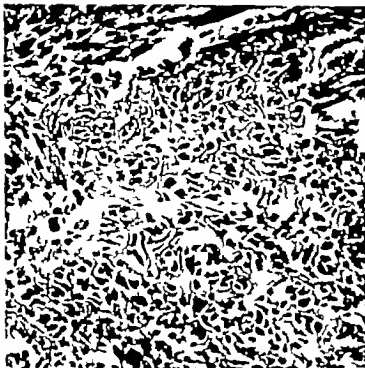


Fig. 1. Osteosarcoma. Well formed anastomosing trabeculae of bone. B.S.R. No. 30.



Fig. 2. Chondrosarcoma. Area of mature cartilage. B.S.R. No. 31.

Fig 3 Chondrosarcoma showing  
spindle cell morphology B S R No  
1188

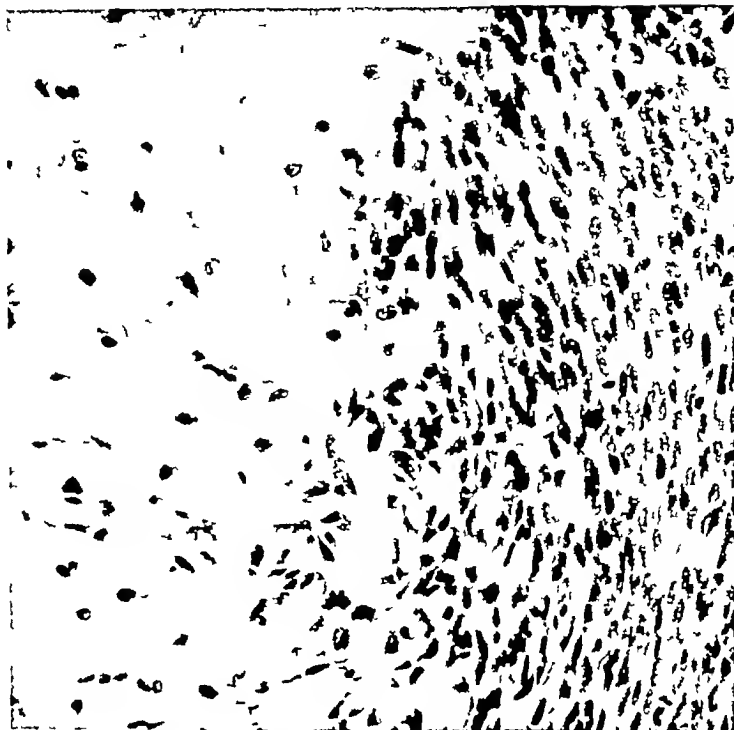


Fig 4 Chondrosarcoma showing  
immature cartilage B S R No 537

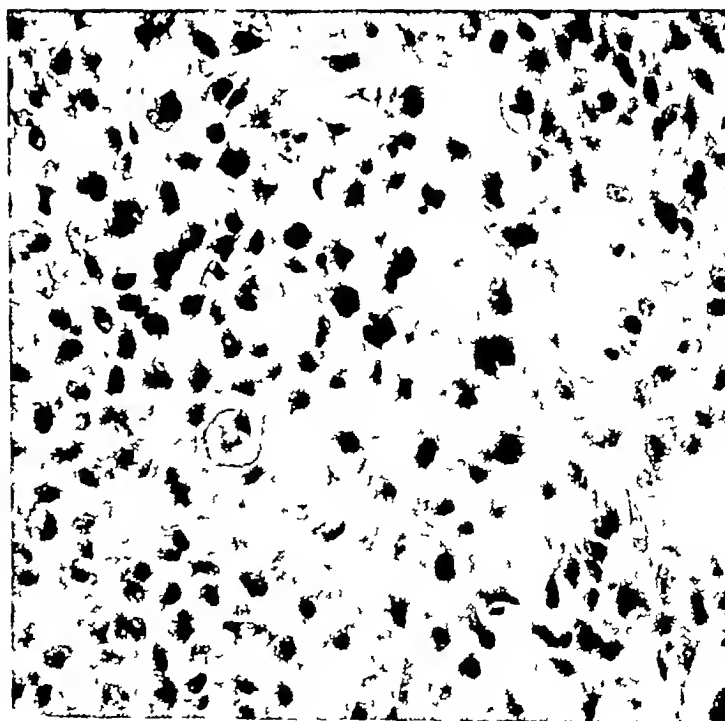




Fig. 5. Calcifying chondrosarcoma.  
B.S.R. No. 456.

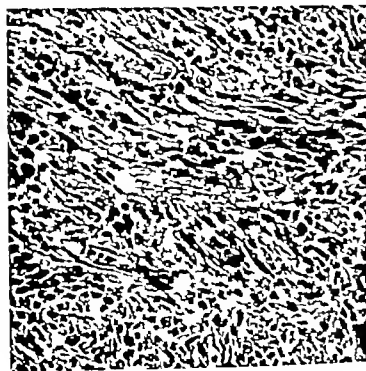
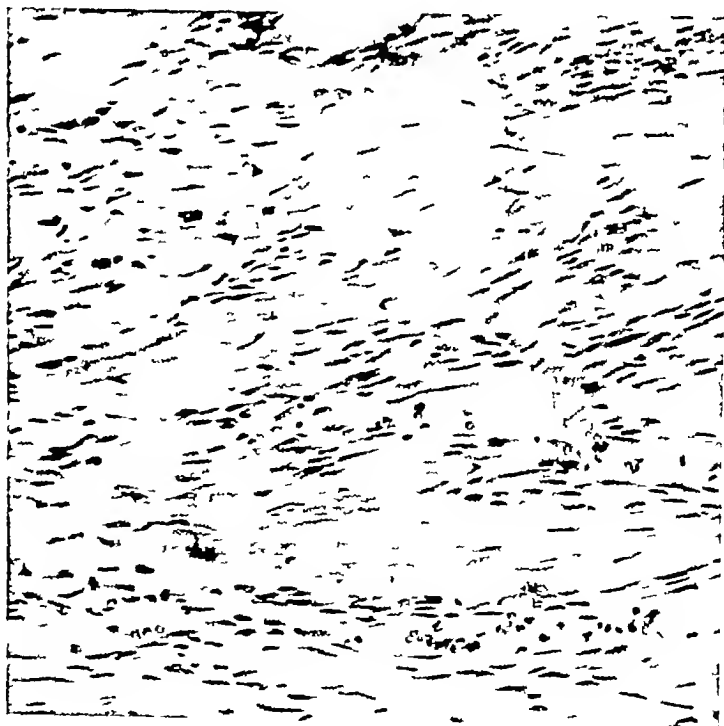


Fig. 6. Primary ovarian fibrosarcoma.  
B.S.R. No. 160.

Fig 7 Fibrosarcoma of bone showing an edematous area B.S.R. No 1108



Fig 8 Ossifying fibrosarcoma of bone S 4508 Children's Hospital





favorable prognostic indication. The material available did not permit an evaluation of this feature in many of the cases, but the results as shown in Table IV indicate that encapsulation is a factor of extraordinary importance.

#### CLINICAL FEATURES

In Table IV are also shown several features of clinical interest. There is an apparent paradox in the fact that the mean period of delay from the onset of symptoms to the time of treatment is considerably greater in the cured than in the uncured cases of osteosarcoma and fibrosarcoma. Ferguson has noted this fact elsewhere and assumed that osteogenic sarcomas have cyclic periods of active growth and relative regression as a part of their natural history and that the favorable time for amputation is later in the disease during a period of lessened activity. We prefer to believe that the explanation lies in the inherent characteristics of the tumor: the highly malignant bone sarcomas exhibiting a more aggressive pattern of growth with early symptoms; early treatment and early metastases. The less rapidly growing tumors or those in which the protective reaction of the host is more intense fail to evoke sufficiently distressing symptoms until a later stage of the disease. One of us has demonstrated an analogous situation in mammary carcinoma. While early treatment must save certain patients it may be assumed that curability depends more upon natural selection than on any other single factor. In this respect chondrosarcoma occupies a median position, the cured and uncured patients having come to treatment after practically identical periods of time.

The possible dangers of biopsy in bone sarcomas are not verified by the incidence in which this measure was employed in the two groups of patients. It is noteworthy that in a considerable number of the cured group the tumors had suffered much graver surgical assaults than simple biopsy. These measures included explorations, curettings, excisions or resections performed at intervals from day to 5 years prior to operation. Twenty-eight, or 23 per cent of the 8 cured patients had suffered some such sort of surgical insult prior to radical treatment while only 6 or 12 per

cent of the 47 uncured patients had been so mistreated. This supports the contention that the advantages of formal biopsy of bone tumors exceed the possible threat of dissemination of a bone sarcoma subjected to such a measure. This conclusion has been repeatedly emphasized by Crowell in his annual statistical analysis of Registry material.

#### SUMMARY

A review of 118 five year cures and 47 fatal results of osteogenic (connective tissue) sarcoma of bone is presented. The importance of primary fibrosarcoma of bone is emphasized and the revival of the term osteosarcoma, to signify those sarcomas characterized by bone production, is suggested. The term osteogenic sarcoma is best used as a generic designation for the triad of connective tissue sarcomas primary in bone: the third member of which is chondrosarcoma.

A comparative analysis of the cases of cured and uncured osteogenic sarcoma indicates that true osteosarcoma is an almost uniformly fatal form of neoplasm accounting for but a fraction of the cures. Fibrosarcoma is a distinctly less malignant form of osteogenic sarcoma while chondrosarcoma seems to occupy a median position occurring in approximately equal proportions among the cured and fatal cases.

A modified classification of these tumors is presented the object of which is to emphasize the basic division of the connective tissue sarcomas arising in bone.

Encapsulation of osteogenic sarcomas is a favorable prognostic element. The amount of matrix has not been proved to be of prognostic value.

Natural selection determines curability to a greater degree than does early treatment for the delay in radical treatment is much greater in the cured than in the uncured neoplasm studied.

Biopsies were performed with more frequency in the cured cases than in the fatal cases.

The value of irradiation as a complementary curative agent in osteogenic sarcoma cannot be inferred from the data shown here. A tual there is no significant statistical difference

evident as a result of irradiation, as approximately half of both the cured and uncured groups, in each of the three types of osteogenic sarcoma, were so treated. This is not to say that irradiation may not be of distinct palliative benefit in many cases.

## REFERENCES

- 1 CROWELL, B. C. *Am Coll Surg*, 1941 Supplement to 26th Year Book, p. 18. Chicago
- 2 EWING, J. *Surg Gyn Obst*, 1939, 68: 971
- 3 FERGUSON, A. B. J. *Bone Surg*, 1940, 22: 1, 92
- 4 PHEMISTER, D. B. *Surg Gyn Obst*, 1930, 50: 216
- 5 *Bull Am Coll Surg*, December, 1935

## GASTROSTOMY FOR RETROGRADE ESOPHAGEAL DILATATION

### A Leak Proof Dressing and Method of Concealing the String

JOEL JAY PRESSMAN, M.D., D.Sc. (Med.), Lieutenant Commander, M.C., U.S.N.R.,  
Los Angeles, California

THE inconveniences due to leakage of gastric or intestinal contents from any gastrostomy or enterostomy fistula, regardless of the purpose for which it was made, need no description. When in addition, for the purposes of retrograde bouginage of the esophagus, there is present the never ending string which passes through the gastrostomy stoma into the esophagus and out the nose, with the two ends tied under the clothing, the hardships suffered are proportionately increased. Since a gastrostomy must often be endured over long periods of time, the economic and social status of the patient becomes important. Many patients are prevented from earning a living and taking their rightful place in society not because of the disease itself, but because of the inconvenience and embarrassment caused by the conspicuous string passing out of the nose and the presence of the leaking gastrostomy fistula.

The method described herein obviates these difficulties, to some extent at least, and patients upon whom it has been used have been universally grateful for their improved status.

Essentially the method suggested consists of plugging the stoma from within. For this purpose the prostatic rubber latex bag designed primarily for use after prostatectomy has been used. Any

simple dilatable balloon with a catheter-like neck would probably prove satisfactory. The prostatic bag presents certain distinct advantages, however, especially in gastrostomies, in that the drainage catheter which passes through it can be used for feeding. The bag illustrated in Figure 1 consists of a dilatable bag, *a*, through which the large catheter, *b*, passes, the bag is built around it but the two do not communicate by any orifice. The catheter projects distally for an inch or more beyond the bag, with its orifice placed on the side at this distal end. Alongside the catheter is a second tube, *c*, considerably smaller in caliber, which terminates within the balloon or bag itself. This is used for dilating the bag. The catheter and smaller tube are enclosed in a common sheath. For gastrostomies a bag with a potential capacity of 75 cubic centimeters is used.

The technique of application is as follows. The catheter is inserted into the gastrostomy wound to a depth at which the bag lies well within the lumen of the stomach. Twenty or 25 cubic centimeters of water or saline are instilled into the bag through the smaller tube, *c*, by means of a Triumph syringe (Fig. 2). The tube is then temporarily occluded by squeezing it between the thumb and forefinger, and the bag is withdrawn until it contacts the anterior wall of the stomach, when rather forceful traction is exerted upon it to determine if the bag has been dilated sufficiently to occlude the gastrostomy orifice completely and can resist traction without being extruded. If not, additional quantities of fluid are added as seem indi-

From the Bronchoscopic Clinic of the Cedars of Lebanon Hospital.

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

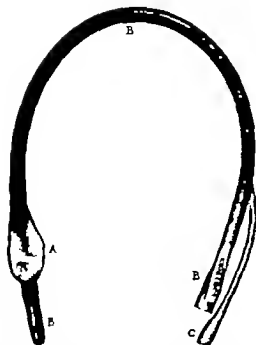


Fig. 3. The bag consists of dilatable bag & catheter. *c*, small catheter tube which terminates in balloon or bag itself.

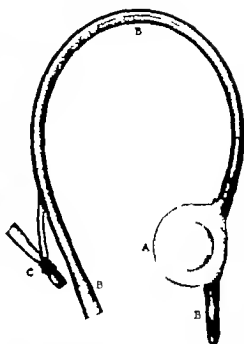


Fig. 4. Same as Figure 3, the bag, *a*, dilated and smaller tube doubled over and tied.

cated, until a state of filling which will accomplish this has been reached. The tube *c* is then doubled over and tied off and for this purpose a length of woven tape is preferred rather than the rubber band shown in the illustration. When this has been accomplished, the bag, for the time being can be allowed to fall back into the stomach with the catheter protruding.

A single 4 by 4 surgical gauze dressing which has previously been split lengthwise, is placed over the wound, the catheter is inserted into the split, and the gauze dressing is then pinned below it. It has been found advantageous as a counter brace to utilize a rounded piece of tin, thin plastic, or wood such as yucca board, or simply a semi-rigid piece of adhesive over cardboard, measuring about 2.5 inches in diameter. A hole large enough to admit the catheter easily is made in the center of it, the catheter is then threaded through the hole, and the disc is lowered to lie on the gauze (Fig. 3).

A spring clip such as is illustrated, or any reasonable modification of it is then threaded over the catheter which is brought through the expanded end of the clip. While one hand holds the dressing down on the abdominal wall the other

withdraws the catheter as far as is possible so that the filled balloon comes to lie snugly against the internal aspect of the abdominal wall with the neck of the balloon protruding somewhat into the gastrotomy stoma. While relatively strong traction is maintained on the catheter the hand holding the dressing is now freed and used to spread the clip applying it across the bag and snugly approximated to the metal disc. The catheter is then curved to lie in any convenient position on the chest or abdominal wall and made fast with two or three adhesive strips. This completes the dressing which can be fully applied in 2 or 3 minutes (Fig. 4). The string attached to the clip in this illustration can be disregarded except when the gastrotomy is for purposes of retrograde dilatation of the esophagus. Its use in this regard will be discussed later.

When feedings are necessary, the patient himself compresses the spring clip, allowing the catheter to fall into its dilated ring and, with a Triumf syringe or other means, instills the feeding through the catheter. When this has been accomplished he then pulls the catheter taut, so that the bag once again comes to lie snugly against the

abdominal wall, and reapplies the clip against the disc. It is of course not necessary to remove the dilating fluid from the bag, or to remove any other part of the dressing. If conveniently located upon the abdominal wall or chest it is not even necessary to remove the adhesive strips holding the catheter. The split gauze is changed once daily, during any one of the feedings. Air is not satisfactory for filling the balloon, and after a fair trial it has been discarded entirely in favor of the fluid.

When properly applied this device is absolutely leak-proof, a "stopper" having been inserted into the stoma from the interior of the stomach. When intragastric pressure is increased, the "stopper" fits all the more tightly. No gastric content or gas whatsoever escapes. The gauze when removed may have a small negligible spot of gastric secretion (but not food) upon it, due to the fact that a margin of gastric mucosa may protrude into the stoma and lie against the gauze, so that the secretion from this very small area stains it a little. If no gastric mucosa protrudes, even this minimum staining does not occur.

No protective ointment next to the skin is required, since I have not seen even the most mild degree of dermatitis, because of the fact that the skin surrounding the stoma is not bathed in gastric juice.

A balloon having a slightly pear-shaped neck seems theoretically to adapt itself better to the contour required. A completely rounded balloon, which might be necessary as a makeshift has not been tried. It might prove equally effective however. It would seem that if the bag were made of sufficiently soft rubber, traction upon the catheter prior to fixing it *in situ* with the clip would naturally result in an entirely round balloon being drawn out a little at this point, thus adapting itself automatically to the shape required for maximum efficiency.

To remove the balloon from the abdominal cavity, it is simply necessary that the tape be removed from the smaller tube, *c*, which is held over a basin, and gentle continued traction against the abdominal wall thereupon results in the bag emptying itself, after which it can be easily withdrawn. If preferred, the fluid can of course be aspirated from the bag by use of a suction syringe.

The patient illustrated wore the bag for almost a year. During this period it was necessary to replace the bag with a new one about every fifth week, since after this time the action of the gastric juice seemed to destroy the elasticity of the rubber. For the first day or two the patient said he was conscious of the presence of the bag, although it occasioned no pain or serious discomfort. After

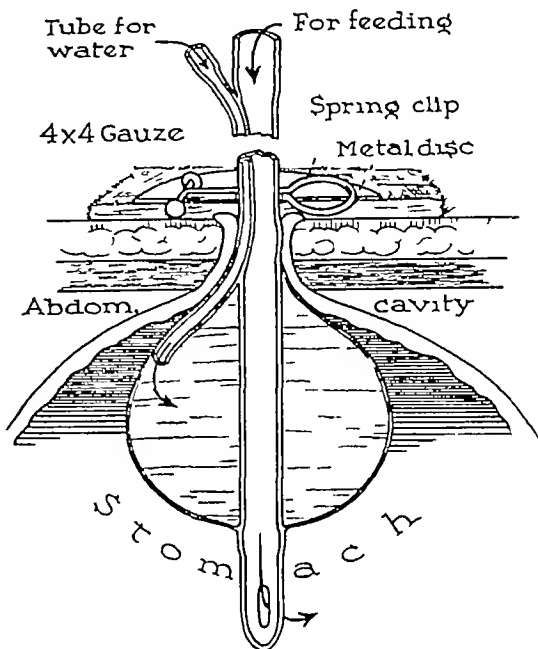


Fig 3 Schematic drawing to illustrate sagittal section through stomach, site of gastrostomy, and dilated occluding bag *in situ*

that he hardly realized he was wearing it, and was able to carry out his work as a musician playing a brass wind instrument. Actually the idea of the bag developed from his complaining that when he attempted to play this instrument with his original conventional dressing, the increased abdominal pressure required by efforts of blowing into the horn resulted in such a profuse escape of gas and fluid that he was forced to discontinue playing even at home, except when his stomach was entirely empty. After the use of the bag was instituted he was able to resume his work professionally and was entirely free of all such complications.

No pressure atrophy of the area has been noted in any case in which the bag has been used.

Besides its use in gastrostomies, this method has been tried in enterostomies and colostomies performed by others. In these cases smaller bags were used. One ambulatory patient who had had a colostomy for several years and who irrigated the colon once a day through a tortuous tract, tried the bag for only 24 hours and preferred to be without it since it created a sense of fullness. In others it proved entirely satisfactory. Dressings remained dry and clean, there was no odor of intestinal contents and no skin irritation occurred.



Fig. 4. Patient with device applied

For use in the colon or small bowel it is a decided advantage to use a smaller bag of a size that does not fill the lumen of the bowel in order to avoid the initiation of peristaltic waves. A flattened balloon built in the shape of a disc rather than an oval or ball would seem the most desirable for use in the intestine but the advent of the war prevented its experimental manufacture. Of course when used for this purpose in the bowel rather than in the stomach it is not necessary that a catheter pass through the balloon. A simple rubber bag with a single inlet tube is sufficient. It can be removed periodically for irrigation of the intestine. There may be some advantage in weaning the patient to the use of the bag, allowing him to wear it at first for a few hours only.

My personal experience with the use of the dressing in enterostomies and colostomies is more limited than for gastrostomies, and I presume that frequently others will have unsatisfactory experiences such as the one I have outlined. Each case is therefore an experiment unto itself and the method will prove successful in some and not in others. It has proved universally successful, however in gastrostomies and for this purpose at least the dressing can be wholeheartedly recommended without reservation.

Under the present circumstances, since it is difficult to obtain stock items, especially of rubber a bag can be improvised from segments of

rubber glove or in thicknesses of condom rubber cemented to a length of small bore rubber tubing.

Opportunity has not yet presented itself of trying the method on tiny fistulas, all the cases reported having been large surgical enterostomies. However it is my opinion that a small enough bag could be made so that it could be introduced into most tracts.

The advantages of preventing leakage of gastric or intestinal contents through a surgical stoma need no emphasis. It is sufficient to say that patients never seem quite so grateful as are those who have been successfully converted from the old type dressing to the new and this applies as well to the nursing staff caring for them.

While the bag described is intended for use in gastrostomies or enterostomies created for any purpose, a further nicety should be mentioned in regard to the care of those upon whom gastrostomy has been performed for the purpose of retrograde dilation of the esophagus and who constantly wear the string required for use with the Gabriel Tucker retrograde bougies. This string remains *in situ* with the esophagus at all times, emerging at one end from the gastrostomic fistula and at the other end from the nose being tied on the outside and forming a never-ending loop. It acts as the guide string by means of which the bougie is drawn upward through the esophagus from below. The presence of the string is not entirely pleasant under any circumstances, but in the adult who mingles in society and attempts to earn a living where he is exposed to the gaze of others, it in itself is a constant source of embarrassment so great that many follow almost a hermit's existence.

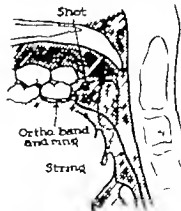


Fig. 5. Schematic drawing showing method of caucal bag string by fastening to nostrils when gastrostomy is performed to permit retrograde dilation of the esophagus

The method of attachment which has been successfully used does not do away with the string, the maintenance of which in the esophagus is necessary for the treatments. It is simply a means of doing away with that portion of it which emerges from the nose, which, however, represents a distinct advantage, at least from the standpoint of social contact and economic activities.

The patient is sent to an orthodontist who places a modified orthodontic band around a lower tooth. Fortunately, in the patient illustrated the last lower molars on each side were missing. The band was therefore placed around the second lower molar. On the posterior aspect of the band there had been built, prior to installation, a small gold circular loop placed horizontally, which came to occupy a portion of the space previously occupied by the third molar. The string is threaded through this loop from below and brought out through the mouth. A split, large sized buckshot with a diameter greater than that of the gold loop is placed on the string with the latter lying within the split which was then squeezed together over the string by means of a small pliers or old heavy hemostat. In this fashion the shot was fixed to the string, and the excess of the latter cut off nearly flush with the shot. Traction is then exerted upon the string from the end emerging through the gastrostomy so that the shot is pulled into the mouth until it contacts the loop on the orthodontic band, coming to rest on its superior aspect (Fig 5). It can of course then go no further because the shot will not pass through the loop which is of smaller diameter. The free end of the string emerging from the

gastrostomy is then tied to the spring clip which fixes the balloon, leaving plenty of excess as shown in Figure 4. The string is worn in this fashion during the entire period between treatments. No string, of course, emerges from the nose and it is impossible to tell by looking at the patient that he is wearing any such appliance.

The second molar need not necessarily be used, but the tooth selected should be a lower one, and the position of the band and loop can be varied according to the ingenuity of the dentist and the dental status of the patient.

When the dilatations are to be carried out, the string is untied at the spring clip on the abdomen, and by means of a hook or small pillar retractor introduced into the pharynx, a loop of string is pulled forward out of the mouth and cut. The distal end is used for the dilatation, as is ordinarily done. The proximal short length still attached to the shot is removed by grasping the shot with a hemostat and extracting it. It is then discarded. Following the dilatation the free end of the string protruding from the mouth is again threaded through the orthodontic loop from below and fixed with the shot as before. It is important during these manipulations to be sure that the length of string protruding from the gastrostomy is sufficiently long so that the end is not withdrawn into the stomach and lost. Extra lengths can be tied on for the purpose.

The plugging of the gastrostomy from within and the elimination of the string protruding from the nose have given most satisfactory results, serving to rehabilitate, socially and often economically, those upon whom it has been used.

# THE ARTERIAL BLOOD SUPPLY OF THE PANCREAS

JOHN M. PIERSON M.S. M.D. Portland, Oregon

An artery supplying the pancreas was first pictured and briefly described by Vesalius in 1564. The supply was more completely described by Winslow, Haller and Bell. Modern anatomy texts have followed the works of Verneuil and other anatomists of the early 19th century, leaving unused the more accurate descriptions of the earlier and subsequent investigators. Since then, Sappey, Wiart, Rio Branco, Brun, Testut, Lipshutz, Romodanowakaja, Adachi, Petró, Wharton, and Ziegler have contributed substantially to our understanding of the vessels supplying the pancreas. Many others have written articles of interest on this subject, but each of the men named has contributed at least one new and important finding which bears on this subject. The reader is especially referred to Petró's monograph on the arterial and venous supply of the duodenum and head of the pancreas (7). The works of Romodanowakaja and Ziegler are also of particular importance.

For the surgeon, any description of the blood supply to the pancreas without some mention of the vessels supplying the duodenum is incomplete, since the relationship of the two organs is most intimate. A concise, accurate description of the arterial supply to the first part of the duodenum is given by Wilkie.

Dissections were made of arterially embalmed and injected cadavers in the anatomy laboratories of the University of Oregon Medical School and of specimens from a topicals which were injected with a gelatin color mass and fixed in 10 per cent formalin solution. In all, 50 dissections were performed. Percentages quoted herein are in some instances computed from slightly less than the total number because of difficulties of dissection encountered in parts of the region dissected. Unless specified, percentages given are of the writer's series of cases. The vascular pattern described has been limited to the most constant vessels and those of greatest surgical significance.

Typically (Fig. 1) the pancreas is supplied by two arteries from the gastroduodenal, two from the superior mesenteric, and one from either the splenic, hepatic, or celiac arteries. In addition to

these a variable number of small arteries arise from the splenic, gastroduodenal, and hepatic. The larger vessels arising from the gastroduodenal artery are the *superior pancreaticoduodenal arteries* (right pancreaticoduodenal of some authors). These are two in number, an *anterior* and *posterior*. They anastomose with corresponding *anterior* and *posterior inferior pancreaticoduodenal arteries* (left pancreaticoduodenal) from the superior mesenteric (Fig. 1). These vessels form two arterial arcades, one on the posterior surface of the head of the pancreas, the other except for its lowermost part, on the anterior surface. They are respectively the *posterior* and the *anterior arcades* of the pancreas. The two inferior pancreaticoduodenal arteries usually arise in a common trunk from the superior mesenteric, the *common inferior pancreaticoduodenal artery*. The *superior pancreatic artery* is the least constant of any of the large arteries to the pancreas. When present, it arises from the splenic, hepatic, or directly from the celiac arteries. In addition to the arteries mentioned, an *inferior pancreatic artery* which passes along the inferior margin of the body to the tail, may take origin from the superior mesenteric, the anterior superior pancreaticoduodenal, the inferior pancreaticoduodenal, or the superior pancreatic artery.

The pancreaticoduodenal arteries are usually at least 2 millimeters in diameter, the superior nearly always being larger than the inferior. The superior pancreatic artery is most commonly 1.5 millimeters and the inferior pancreatic 1.0 to 1.5 millimeters in diameter. All the vessels mentioned are usually .50 to .75 millimeters in diameter.

The *gastroduodenal artery* (Figs. 1, 2, 3, 6) arises from the hepatic just dorsal and slightly superior to the junction of the pylorus and the duodenum. Whereas the hepatic passes upward in the hepatoduodenal ligament, medial to the common duct and anterior to the portal vein, the gastroduodenal courses downward, medial to the common duct and dorsal to the first part of the duodenum, terminate at its lower border by dividing to the right gastroepiploic and anterior superior pancreaticoduodenal arteries. As the gastroduodenal passes dorsal to the superior margin of the duodenum, it gives off the posterior superior pancreaticoduodenal artery. The smaller branches are given off at the first part of the

From the Departments of Anatomy and Surgery, University of Oregon Medical School. Prepared under the direction of Dr. Robert S. Daw and Dr. John A. Gray.

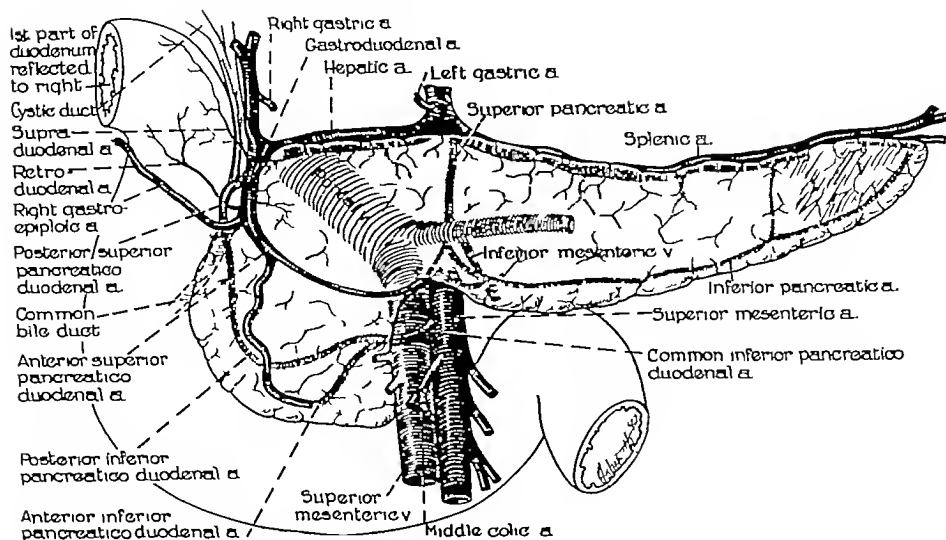


Fig 1 Diagrammatic representation of the typical arterial supply of the pancreas Anterior aspect

duodenum (Figs 1, 5) the *supraduodenal artery* to the superior wall and most of the anterior surface, and the *retroduodenal artery* (Fig 1) arising one-half inch above the bifurcation of the gastroduodenal and supplying the lower two-thirds of the posterior wall, sometimes extending as far as the second part. The remainder of the first part of the duodenum is supplied by branches from the pyloric, the right gastroepiploic, and the superior pancreaticoduodenal arteries. A few variable and unnamed branches are usually given to the head of the pancreas.

The *posterior superior pancreaticoduodenal artery* (Figs 1, 3, 4, 5, 6) (superior right pancreaticoduodenal) is a surgically important artery, 2 millimeters in diameter, which has escaped mention in modern textbooks of anatomy in spite of its occurrence in 96 per cent of the 50 cases dissected. Edwards found this artery in 97 per cent of 100 cadavers but mistook it for the *retroduodenal artery* described by Wilkie. It takes origin from the right dorsal side of the gastroduodenal and in 86 per cent of cases (Petrén) passes to the right and inferiorly across the anterior surface of the common bile duct. It then curves downward from the right side of the duct toward the left, crossing dorsal to the intrapancreatic part. Thus, the common duct passes through an arterial loop formed by this artery (Figs 1, 4, 5). Petrén found that in 14 per cent of cases the gastroduodenal artery lies directly anterior to the common duct where this artery comes off. In these cases the anterior part of the loop is absent (Fig 3). It

passes downward in an arc to anastomose with the posterior inferior pancreaticoduodenal artery. As it loops over the common bile duct, it nearly always contributes small branches to it (Figs 1, 5). Commonly one of these extends up the wall of the common and cystic ducts (Fig 5), sometimes being developed to such a degree as to form an accessory cystic artery. Section and ligation or transplantation of the common duct might lead to necrosis by interfering with these blood vessels. This may explain the leakage of bile common after these procedures.

The posterior arcade is usually situated cephalad to the anterior arcade. The fine branches of the posterior arcade anastomose with each other, forming secondary and tertiary arcades more frequently than do those of the anterior arcade (Fig 4). Short branches from it supply pancreatic tissue, longer, more superficial branches supply the duodenum.

The *anterior superior pancreaticoduodenal artery* (superior pancreaticoduodenal, right inferior pancreaticoduodenal) arises as a terminal branch of the gastroduodenal in 100 per cent of the cases examined (Figs 1, 2, 6). It comes off just above the lower wall of the first part of the duodenum. In 76 per cent of these cases the arcade passes directly downward and then curves slightly to the left over the anterior surface of the head of the pancreas, many times being partially imbedded in it but nearly always visible from in front (Fig 2). This first part of its course lies 1.5 to 2 centimeters away from the anterior groove between



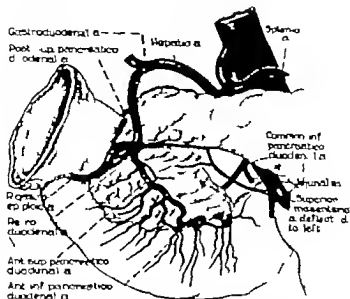


Fig. 2 The most common arrangement of the anterior pancreatic arcade. Anterior aspect of the pylorus and first part of duodenum reflected to the right. (Modified from Petén.)

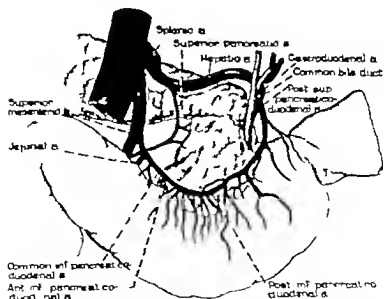


Fig. 3 Posterior aspect of the specimen in Figure 2 showing relations present in 4 per cent of cases. The gastroduodenal artery lies directly anterior to the common bile duct. (Modified from Petén.)

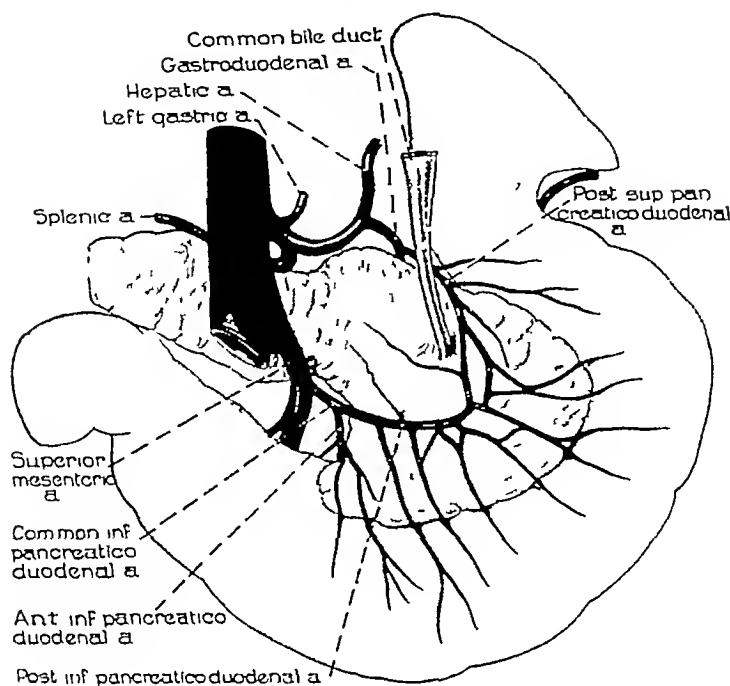


Fig 4 The most common arrangement of the posterior pancreatic arcade. Posterior aspect with pylorus and first part of duodenum reflected to the right. (Modified from Petré)

pancreas and duodenum. As it descends, it approaches the groove more closely until at the junction of the horizontal and the ascending parts of the duodenum it reaches the groove. It then bends sharply around the inferior margin of the pancreas, or passes through it. Finally it passes dorsally and up ward to the left to lie in its last fifth on the posterior surface of the head of the pancreas, or within the substance of the gland. That portion of the arcade lying on the anterior surface of the gland is often quite tortuous. In 24 per cent of cases the anterior arcade lies throughout its course on the anterior surface of the head of the pancreas. In these cases, although the arcade approaches the groove between gland and duodenum, it never attains it.

The anterior and posterior inferior pancreaticoduodenal arteries (Figs 1, 2, 3, 4, 6) may arise either in a common trunk (62 per cent) or separately (38 per cent) from the superior mesenteric (60 per cent), the first jejunal (26 per cent), or the middle colic artery (14 per cent). They usually (in 64 per cent) arise posteriorly from the superior mesenteric or jejunal arteries. In 36 per cent of cases they arise from the right side, the anterior

surface, or the left side of the superior mesenteric artery. Nearly always those arising from a jejunal artery come off dorsally. The origin of these vessels is usually at the lower margin of the neck of the pancreas, but they may come off high behind the pancreas. The duodenojejunal flexure is supplied mainly by branches from one of the inferior pancreaticoduodenal arteries, the first jejunal making a minor contribution to it. In cases in which these vessels may be destroyed it is suggested that the surgeon excise the proximal 1 or 2 inches of the jejunum.

The inferior pancreatic artery (Fig 1) is constant according to Wharton, who found it present in 100 per cent of 30 dissections and corrosion preparations. It may take origin from the superior mesenteric, the anterior superior pancreaticoduodenal, the inferior pancreaticoduodenal, or the superior pancreatic artery and usually receives connections from two or more of these. It passes from the right toward the tail imbedded in the dorsal surface of the body of the pancreas and lies entirely within 3 centimeters of the inferior margin of the gland. It receives anastomoses from pancreatic branches of the splenic artery.

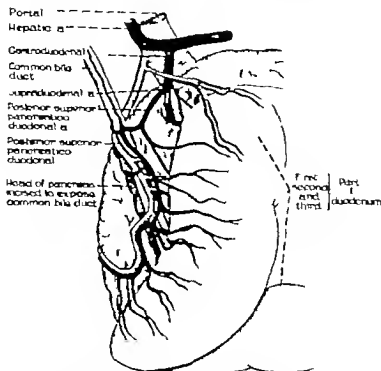


Fig. 5. Vascular distribution about the common bile duct as viewed from the right. The duodenum and attached pancreas are reflected medially. (Modified from Rio Branco.)

The *superior pancreatic artery* (Figs. 1, 3, 6) (great superior pancreatic—Haller) is present in 54 per cent of cases and is quite variable in size. Although usually about 5 millimeters in diameter it varies from 1 millimeter to nearly 1 centimeter. This vessel arises from the first centimeters of the splenic or hepatic artery or from the celiac axis. It may give origin to the middle colic artery (Fig. 6) (4 per cent) or may anastomose with it (4 per cent). This artery passes dorsal to the neck or body of the pancreas and the splenic vein. It divides into a branch which passes to the anterior surface of the head to anastomose with a fairly constant branch of the anterior superior pancreaticoduodenal artery (Figs. 2, 6). The other branch courses to the left where it usually communicates with the inferior pancreatic artery and may give origin to it. The superior pancreatic artery is not described in any of the standard textbooks.

The other pancreatic branches (Figs. 4, 6) (lesser pancreatic) from the splenic artery are

usually quite small, but occasionally one may attain 2 millimeters in diameter. They immediately ramify in the substance of the gland, anastomosing with one another and with the inferior and superior pancreatic arteries. They vary in number from two to nine and are always present.

Pancreatic branches of the gastroduodenal (Fig. 5) are common but variable. They occur in 62 per cent of cases. Most of them tend to occur near the termination of this artery.

Branches of the hepatic supplying the pancreas (Fig. 5) are inconstant and variable. Vessels 1 millimeter or larger in diameter are present in only 10 per cent of cases. They vary in number from one to four and tend to be present when the hepatic is unusually long or imbedded in the pancreas.

The middle colic artery may have several important relations to the pancreas. It may arise high on the superior mesenteric and be in contact with the pancreas for short distance. I once case observed it passed through the head of the pancreas, having its major bifurcation while im-

\*There is not to be confused with the great pancreatic of some textbooks, which anastomoses to the duodenum more inferiorly than as described.

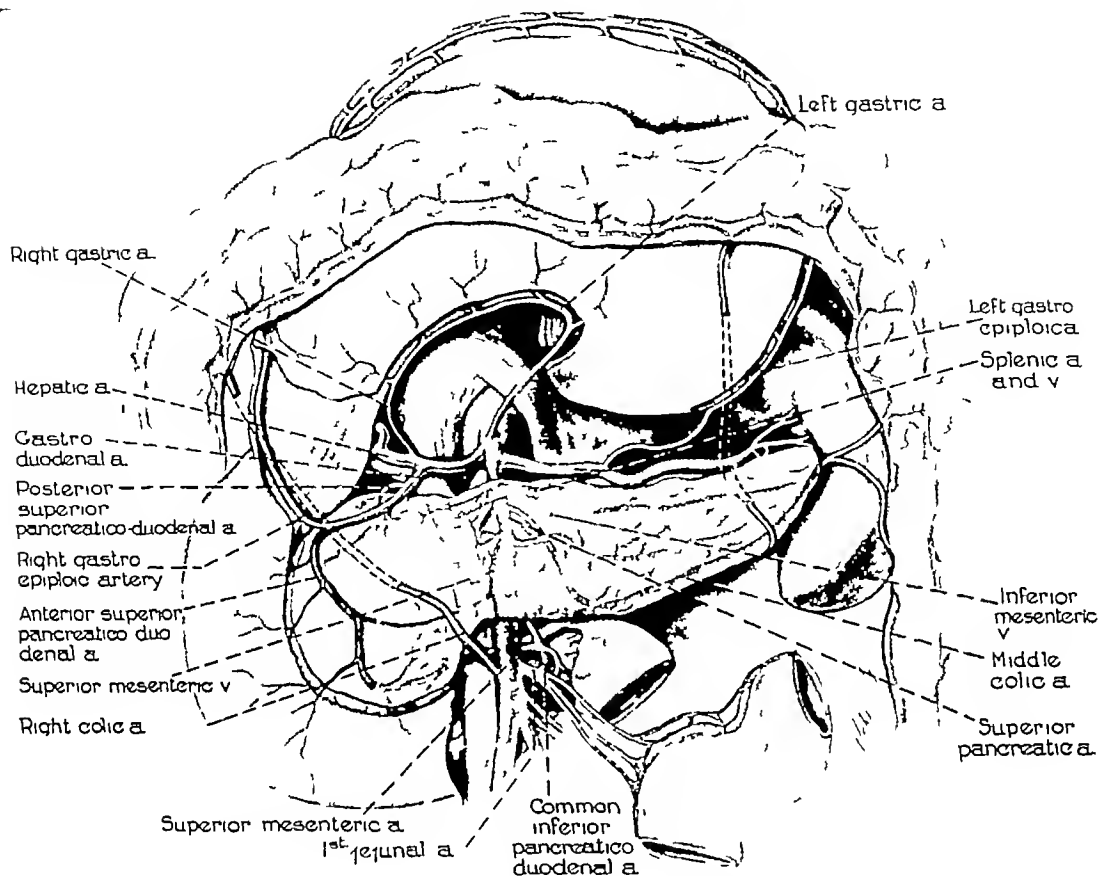


Fig 6 Specimen in which the middle colic artery takes origin from the superior pancreatic. The transverse colon and stomach are reflected upward. Note that the right

colic artery passes directly to the hepatic flexure of the colon and that the middle colic artery passes to the splenic flexure.

bedded in the gland. The middle colic may divide near its origin into two or three fair-sized vessels, one of which, en route to the splenic flexure, may lie imbedded in the pancreas along its inferior margin or in the posterior capsule of the gland. Figure 6 shows one of two cases observed in which the middle colic artery took its origin from the superior pancreatic. Ziegler describes two cases in which the middle colic artery took its origin from the gastroduodenal.

An anomalous hepatic artery arises from the superior mesenteric in 10 per cent of cases (8 per cent right hepatic artery, 2 per cent an accessory hepatic). When present, it passes dorsal to the head of the pancreas into the hepatoduodenal ligament, often lying dorsal to the common bile duct. The cystic artery has a similar origin and course in 4 per cent of cases. These

anomalous hepatic and cystic arteries always give origin to large branches which supply the posterior surface of the gland and contribute to the posterior arcade.

The relationship of the arteries to the veins is fairly constant. Every artery here described has a concomitant vein. According to the writer's observations, as well as Petré's, the veins usually lie nearer the surface of the gland than the arteries. The anterior superior pancreaticoduodenal vein drains constantly into the right gastro-epiploic vein, which is a tributary of the superior mesenteric. The posterior superior pancreaticoduodenal vein almost always drains directly into the portal vein (Fig 5). The lower veins empty directly into the superior mesenteric or one of its tributaries. The posterior inferior pancreaticoduodenal vein may empty into the inferior

mesenteric. The splenic vein which is sometimes imbedded in the gland, receives several veins from the body and tail.

#### SUMMARY AND CONCLUSIONS

A brief review of the literature on the circulation of the pancreas is presented. Observations on the arterial circulation of the pancreas in 50 cases are reported. The arterial supply of the pancreas though variable follows a fairly constant pattern. The anterior and posterior arcades lie on the respective surfaces of the head of the gland. Arteries supplying the pancreas found in this study are

Anterior superior pancreaticoduodenal in 100 per cent of cases	} form the anterior arcade
Anterior inferior pancreaticoduodenal in 100 per cent	
Posterior superior pancreaticoduodenal in 96 per cent	} form the posterior arcade
Posterior inferior pancreaticoduodenal in 100 per cent	
Inferior pancreatic in 100 per cent (Wharton)	
Superior pancreatic in 54 per cent	
Pancreatic branches of the splenic in 100 per cent	
Pancreatic branches of the gastroduodenal in 63 per cent	
Pancreatic branches of the hepatic in 10 per cent	

The vessels supplying the first part of the duodenum are the supraduodenal, the retroduodenal, and branches from the pyloric, the right gastropiploic, and the superior pancreaticoduodenal arteries.

The arterial loop formed by the posterior superior pancreaticoduodenal artery around the common bile duct is described. Branches from this vessel supply the common duct. It is suggested that damage to this blood supply may result in leakage of bile following ligation or transplantation of the common duct.

The veins of the pancreas follow the general course of the arteries but lie superficial to them.

Attention is directed to the posterior superior pancreaticoduodenal, the inferior pancreatic and the superior pancreatic arteries, which, although of important size and relatively constant occurrence, are uniformly neglected in descriptions of the pancreatic circulation found in standard anatomy textbooks.

Since the duodenojejunal flexure is supplied mainly by branches from one of the inferior pancreaticoduodenal arteries, it is recommended that in procedures which might interrupt these vessels the proximal 1 or 2 inches of the jejunum be excised.

#### REFERENCES

1. Adams, B. *Die Arterienversorgung der Japaner*. Vol. Kyoto Maruzen Co. p. 5.
2. Ball, J. *The Anatomy of the Human Body*. Vol. Edinburgh, G. H. & Son, 1907.
3. Brix, H. *Beitr. klin. Chir.* 9: 84, 203-213.
4. Edwards, L. F. *Anat. Rec.* 94: 35-355.
5. Haller, L. *Disquisitiones Anatomicae Selectarum*. Vol. 3. Gotingae. Urban Vandenhoeck, 1741.
6. Lemaire, B. *Ann. Surg.* 9: 65, 30-69.
7. Petrucci, T. *Zucker Anat. Litu.* 939, 90, 34-77.
8. Rio Branon, Do. *Essai sur l'anatomie et de la méthode opératoire du tronc coelomique et de ses branches, de l'artere hépatique et pancréatique*. Thèse, Paris, 0.
9. Rouvière, J. *Z. Zucker Anat. Entz.* 936, 70, 306-314.
10. Surry, P. C. *Traité d'anatomie descriptive*. Tome 2. Paris. Veuve Delaunay, 1819.
11. Turrel, L. and O. Jacob. *Traité d'anatomie topographique*. 4<sup>e</sup> éd. Tome 1. Paris. Océa. Dela et Fils, 914.
12. Verneuil, A. *Mémoire sur quelques points de l'anatomie du pancréas*. Gaz. méd. Paris, 45 (From Petrus, 7).
13. Verneuil, A. *Anatomie totale, avec l'écrit de l'homme*. Paris, 504.
14. Warton, G. K. *Anat. Rec.* 932, 53, 55-8.
15. Willet, J. B. *Recherches sur la forme et les rapports du pancréas*. J. Anat. physiol. Paris, 309 (From Petrus, 7).
16. Wille, D. J. D. *Surg. Gyn. Obst.* 9: 300-305.
17. Wille, J. B. *Exposition anat. de la structure du corps humain*. Paris, 73 (From Petrus, 7).
18. Ziegler, H. R. *Surg. Gyn. Obst.* 94, 74, 37-445.

# THE EFFECT OF ESTROGENIC SUBSTANCE UPON UTERINE MOTILITY DURING LABOR

## A Study of 42 Patients with the Lorand Tocograph

DOUGLAS P. MURPHY, M.D., F.A.C.S., Philadelphia, Pennsylvania

**I**N a previous report (1) we described the effect of estrogenic substance upon uterine motility during late pregnancy. The uterus reacted only after the 28th week of gestation, the incidence of response increased progressively as pregnancy advanced, the drug influenced both the tone of the uterus and the intermittent contractions, but the occurrence, the nature, and the degree of the responses were unpredictable.

The present study concerns the effect of estrogenic substance upon uterine motility during labor and was undertaken in order to discover how it influences activity at this time.

### MATERIALS AND METHODS

Patients on the ward service of the Hospital of the University of Pennsylvania acted as subjects. Observations were conducted between September 9, 1942, and January 12, 1943. Uterine contractility was registered with a Lóránd tocograph. Estrogenic substance, in the form of  $\alpha$ -estradiol dissolved in sesame oil, was administered intramuscularly. Observations were made early in the first stage of labor when possible. The uterine contraction pattern was registered continuously for an hour. The estrogenic material was given 15 minutes after the tocographic record was begun.

### RESULTS

Of 42 patients who were treated, 17 gave a uterine reaction. Ten experienced an increase in tone. Seven registered no increase in tone but did exhibit slight alterations in the character of their intermittent contractions.

Representative examples of increases in tone are illustrated in Figures 1 to 5b inclusive. The reaction time averaged 19 minutes and 48 seconds  $\pm 9$  minutes. The rises in tone were abrupt in some patients (Figs. 1 and 2) and less so in others (Figs. 3 and 4). In all patients the increase in tone after treatment persisted throughout observation.

One patient who reacted with an increase in tone received a second treatment after an interval of 4 hours and again reacted in a similar manner, as shown in Figures 5a and 5b.

The estrogenic substance altered the intermittent contractions of only 7 patients. One experienced a slight increase in the frequency of her contractions, 3 exhibited an increase in both the frequency and the strength, 2 showed an increase in the rhythmicity, and 1 had an increase in the strength and duration. The effects of the drug upon these 7 patients were so minimal that the reactions were not considered significant.

### EVALUATION OF STUDY

The findings of our previous study (1), together with those of the present one, indicate that estrogenic substance influences uterine motility. When administered during labor it appears to effect primarily the tone of the uterus.

Our chief interest in the study of uterine activity during pregnancy and labor centers around the discovery of some means whereby slow labor may be expedited. In two earlier studies we noted that the tone of the uterus tends to increase during late pregnancy (2), and likewise during labor (3). In recording the contraction pattern of patients who experienced primary inertia, we found that they usually exhibited uterine contractions small in magnitude and variable in their other characteristics (4). In addition such patients usually experienced a low uterine tone.

Since our observations indicate that a certain increase in tone is to be expected during labor, a drug which raises uterine tone ought to have value in the treatment of patients suffering from primary inertia. The observations forming the basis for this report were made upon patients experiencing normal labors. It is possible that estrogenic substance might raise the uterine tone of such patients but have no appreciable effect upon patients suffering from primary inertia. As primary inertia continues to be a major obstetrical problem, it would seem of value to study further the effect of estrogenic substance upon uterine motility. Such investigations are now in progress.

From the Coe Hospital Institute of Gynecologic Research, Department of Obstetrics and Gynecology, University of Pennsylvania. Aided in part by a grant from Ciba Pharmaceutical Products, Inc.

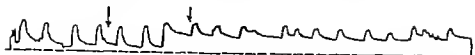


Fig. 1. Patient B. C., tracing 2,447. Observation of uterine motility made during first stage of labor lasting 73 minutes and 48 seconds. At left-hand arrow .354 milligram of  $\alpha$ -estradiol was administered intramuscularly. At

right-hand arrow 54 minutes and 54 seconds later note increase in tone, as indicated by the higher level of the trough of the preceding wave, above the base line.

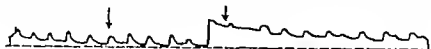


Fig. 2. Patient D. S., tracing 2,320. Observation of uterine motility made during first stage of labor lasting 66 minutes and 36 seconds. At left-hand arrow .708 milligram of  $\alpha$ -estradiol was administered intramuscularly. At

right-hand arrow 58 minutes and 36 seconds later note increase in tone.

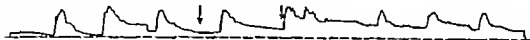


Fig. 3. Patient D. S., tracing 2,567. Observation of uterine motility made during first stage of labor lasting 83 minutes and 6 seconds. At left-hand arrow .154 milligram of  $\alpha$ -estradiol was administered intramuscularly. At

right-hand arrow 5 minutes and 54 seconds later note increase in tone.

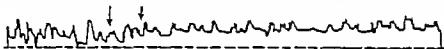


Fig. 4. Patient L. W., tracing 2,348. Observation of uterine motility made during first stage of labor lasting 69 minutes and 54 seconds. At left-hand arrow .354 milligram of  $\alpha$ -estradiol was administered intramuscularly. At

right-hand arrow 6 minutes and 54 seconds later note increase in tone.



Fig. 5a. Patient L. C., tracing 2,304. Observation of uterine motility made during first stage of labor lasting 76 minutes and 48 seconds. At left-hand arrow 0.354 milligram of  $\alpha$ -estradiol was administered intramuscularly. At

right-hand arrow 35 minutes and 48 seconds later note increase in tone.

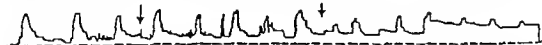


Fig. 5b. Same patient as in Figure 5a. Tracing 2,303. Observation of uterine motility made during first stage of labor, begun 9 hours and 58 minutes after onset of tracing in Figure 5a. At left-hand arrow .708 milligram of

$\alpha$ -estradiol was administered intramuscularly. At right-hand arrow 5 minutes and 30 seconds later note increase in tone.

#### SUMMARY AND CONCLUSIONS

1.  $\alpha$ -Estradiol was administered intramuscularly to 43 women during the first stage of labor simultaneously with the recording of their uterine activity with a Lördin tocograph.

2. Seventeen patients registered a uterine reaction to the drug: 10 experienced a significant increase in uterine tone; 7 exhibited insignificant

increases in the characteristics of their intermittent contractions.

#### REFERENCES

1. MONTGOMERY D. P. Surg. Gyn. Obst. 94:3, 76-426.
2. Ibid. 94:3, 74-8.
3. Ibid. 94:3, 76, 60.
4. Ibid. 94:3, 77-70.





position of the patient during operation also has been demonstrated to be an important factor in the frequency with which postoperative atelectasis occurs. Gray found that he could reduce the incidence of postoperative complications approximately 30 per cent by simply placing the patient in the Trendelenburg position during and after operation.

If postoperative atelectasis occurs, it invariably develops within the first forty-eight hours after operation. In fact evidence would seem to indicate that it is likely to occur before the patient recovers consciousness from the anesthesia. One would assume therefore that the factors involved in its development were present during the course of the operation. Postoperative atelectasis is not in itself a serious complication. Its danger lies in the fact that it may be the precursor to the development of true bronchopneumonia.

Most patients on recovering consciousness following operation are able to expel the secretions retained in the tracheobronchial tree without a great deal of difficulty and if atelectasis has occurred it will subside promptly with expulsion of these retained secretions. This usually occurs within the first forty-eight hours after operation. Frequently a patient who has atelectasis can be encouraged to expectorate any retained plug of mucus by support of the operative wound at the time of cough. If however the obstruction is allowed to remain in the bronchus and secondary pulmonary infection occurs, as it is likely to do then atelectasis is but the precursor of pneumonia.

It is apparent, therefore that in order to decrease the incidence of postoperative complications following operation, it is important to eliminate the factors that gave rise to their development. The most important preventive measure is the prompt removal of secretions in the tracheobronchial tree before dur-

ing, and immediately after operation. This should be carried out while the patient is on the operating table and a patient who has secretion in the airways should never be allowed to leave the operating room before the secretion has been thoroughly aspirated. Harrington has expressed the opinion that in cases in which operation has been done on the thorax, and following any operation in which atelectasis is suspected roentgenograms should be made while the patient is still on the operating table to be certain that a region of atelectasis may not be overlooked.

In many cases, the aspiration of retained secretion in the airways can be accomplished by the use of an aspirating catheter inserted through an intratracheal tube or directly into the larynx with a laryngoscope during and immediately after the operation. Frequently however the secretion may be beyond the reach of a catheter or so viscid that it cannot be removed adequately by this method. In cases of this type, bronchoscopic aspiration of the tracheobronchial tree becomes essential to prevent the development of atelectasis. Bronchoscopy also is indicated in cases in which there is evidence of atelectasis which cannot be relieved by the more conservative measures. The procedure itself is relatively simple and can be performed without risk or undue discomfort to the patient. To be effective, however bronchoscopic aspiration must be employed before secondary infection and pneumonia are superimposed on the primary atelectasis. The prompt aspiration of retained secretions from the tracheobronchial tree by catheter or bronchoscopy during and after operation until consciousness is recovered and the normal cough reflex is fully restored will reduce the occurrence of postoperative complications to a minimum.

In spite of the outstanding work of Lee and Tucker who demonstrated that bronchoscopic

removal of retained secretion in the bronchus brought about a prompt disappearance of atelectasis, this method of treatment was slow in being accepted. Only within the past few years has it been employed more and more extensively in the prevention and treatment of postoperative atelectasis.

The problem presents itself as to the person best qualified to carry out bronchoscopic aspiration of the tracheobronchial tree during and following operation. The ideal situation would be for a trained and experienced bronchoscopist to be available for this procedure. This, however, is not always feasible. In certain instances the surgeon may have the training necessary to perform bronchoscopy, especially if he is interested in thoracic disease, but this is the exception rather than the rule.

It would appear that the trained anesthetist would be in an especially favorable position to take over this duty. It is the anesthetist who watches the patient most closely for evidence of aspirated secretion and vomitus during operation and immediately thereafter. With his training and skill in the introduction of intratracheal tubes, he should be especially adapted to learning the technique of bronchoscopy. Undoubtedly, in the not far distant future every qualified anesthetist will be required to have fundamental training in the field of bronchoscopy.

HERMAN J. MOERSCH

## THE "ALL OUT" ANESTHETIC AGENT FOR GENERAL ANESTHESIA IN ARMED FORCES AND CIVILIAN DEFENSE

THE position has been taken by teachers of anesthesiology that a routine agent and method of administration of anesthetics should be discouraged, that the

anesthetic agent and the method should be suited to the case. This policy entirely overlooks two important factors upon which subsequent mortality and morbidity depend: (a) judgment required for selection—as in other fields this cannot be taught but is acquired through well balanced experience, and (b) the technical skill necessary to make the judgment effective—technical skill comes slowly, for some it is impossible, it is a physical qualification which many do not possess.

The anesthetic is administered to the patient in order that the surgeon may operate with safety and convenience and that the patient may have an uncomplicated recovery. Should these factors be jeopardized by the use of some new anesthetic, administered by a man who has spent but a few months learning a list of new anesthetic agents and techniques which he is to employ with what skill he can muster, under the conditions faced at the moment? Should casualties be looked upon as opportunities for the scientific education of the personnel administering the anesthetics or should the safe evacuation of the wounded, with the factors contributing to this end—the anesthetic, asepsis, and the intravenous therapy—be the surgeon's first and last concern in selecting the anesthetic to be used?

The alternative to the practice of using the many new agents and the new methods of inducing anesthesia now in vogue is a well considered routine which has been found to be safe and effective, is under control, and is accompanied by few regrets. The agent selected must be capable of fulfilling, to the degree indicated by the extent of operating necessary in a given case, the following basic surgical requirements, namely: controlling pain (dressings), producing unconsciousness, controlling superficial reflexes (débridement, foreign body removal, etc.) causing muscular relaxation (extremity work), controlling deep reflexes

(abdominal surgery) and finally permitting a reasonably rapid return to consciousness (reduced postoperative care)

The anesthetic agent must be capable of safe administration for the performance of surgery upon the extremities, the abdomen, the head and neck, and also of plastic surgery. It should be capable of intravenous administration in saline, glucose, plasma, or whole blood. It should be capable of use for painful dressings, for induction of general anesthesia, and to replace other agents. It should be capable of administration by improvised means and by simple portable apparatus. It should be easily available and should not be subject to explosion or to burning from undetectable sources of ignition. It is obvious that cyclopropane, ethylene, ethyl chloride, chloroform, nitrous oxide gas and oxygen, the intravenous barbiturates—evipal, pentothal sodium—and avertin, also that regional block, caudal or spinal anesthesia cannot meet these requirements.

A personal experience of more than thirty years with ether as an anesthetic agent has satisfied the author that the claims made for other agents and methods suggested as basic routines cannot be sustained. Numerous reasonable objections to the use of ether have become common knowledge, but it is most unfortunate that equally well known and accepted methods of meeting these objections have been generally ignored. Instead new agents are continually being introduced but with accumulating morbidity and mortality percentages, the use of the newcomer is gradually eliminated and another aspirant promptly takes its place.

□ The objections to the use of ether are: difficulty of administration; lack of uniformity in purity in manufacturer; in containers; and in preservation; flammability; tendency to cause dehydration and hemoconcentration; loss of

liver glycogen; hyperglycemia due to anoxia; loss of body heat; excessive salivation; tendency to postoperative pulmonary complications; postoperative nausea and vomiting.

Difficulty of administration is technical. Ether which is marked "for anesthesia" is now safe for use. Ether and air occasionally burn; explosions however are very rare. Intravenous therapy now a matter of routine, eliminates dehydration, hemoconcentration, and glycogen loss. Anoxemia is no longer tolerated. Salivation is controlled by preoperative medication. Postoperative pulmonary complications always have been due to the aspiration of secretions and to anoxia. Postoperative nausea is caused in 90 per cent of cases by anoxia and in 10 per cent by the odor of ether.

With the casualty medicated for pain (morphine) and with the anesthesia induced by the intravenous administration of ether in saline, glucose or plasma, or by means of an improvised towel cone, a pharyngeal tube, a pocket flash light laryngoscope and an endotracheal tube—every type of war or civilian surgery can be carried out safely, effectively and with minimum morbidity and mortality. The addition of a simple inhaler, nitrous oxide gas and oxygen, and a mechanical suction apparatus makes for luxuries which not only will render control easier but will likewise reduce the morbidity.

If such a basic routine is not only feasible but may be expected to meet the surgical requirements of all casualties encountered—the author has thus successfully anesthetized in civil practice patients with every condition referred to—then why not provide the technical skill required to carry out the practice? Intelligent hands are needed to do this job directed by professional experience by men who have the whole picture in mind rather

than the promotion of some new anesthetic agent and method of administration

The policy outlined does not make for glamor in the field of anesthesiology. The method is not spectacular. It will be viewed as retrogressive by those who place emphasis on equipment rather than upon ultimate broad scale results. Requisite technical skill is not easily acquired, it is a physical qualification which many men do not possess. Conversely, a perfect technical act may be per-

formed with little knowledge of its implications

On the other hand this policy may be depended upon to reduce the incidence of sudden death—the embarrassment of the expert who finds that his special apparatus or gases have not arrived or are out of commission—and, finally, to eliminate the unwise employment of agents and techniques not suited to the hazards faced in the operation at hand

PALUF L J FLAGG

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

**A**n excellent manual on oxygen therapy technique, *Manual of Oxygen Therapy Techniques* by Albert H. Andrews, describes briefly but clearly the various accepted methods of oxygen administration, namely tent, catheter and mask together with the slight differences in technique required to use efficiently the different types made by the various manufacturers.

The author also summarizes the effectiveness of the various methods in a table headed Factors Affecting Choice of Administrative Methods. This, as he states, reveals that single method of administration can entirely replace either or both of the other methods.

The book should be valuable to all those concerned in the administration of oxygen therapy.

WALTER M. BOORER

**T**HE excellent volume *Operating Room Techniques* is for nurses and will be of great value to students, graduate nurses, and operating room supervisors. The make-up of the book is well planned, the type is legible, the pages large for easy reference, and the paper of good quality. The book is profusely illustrated but it is unfortunate that more sequence photographs, such as the first three in Chapter V, are not used.

The first third of the volume is devoted to operating room fundamentals of which the chapters on personnel of the operating room, standardization of duties, and precautions are unusually good. The portion of Chapter VIII pertaining to absorption of catgut is not in agreement with the recent literature, nor is any mention made of cotton as suture material. The chapter on sterilization should be more complete for example no mention is made of rinsing catheters after being sterilized in formaldehyde. Likewise, no illustration or description is given of sponges, laparotomy pads, laparotomy sheets, etcetera, as to size, how made and folded. The chapter on draping the patient is excellent. Unfortunately, the photographs infer the nurses should drape the patient. The chapter and illustrations on surgical positions are excellent but the illustration of the positions might better precede each set of operations. A section with appropriate illustrations pertaining to hand signals for forceps, scissors, sutures, ligatures, knife and syringe would be of great aid. Also para-

graph on how to pass instruments, sutures and ligatures should have been included.

The last two-thirds of this work is a procedure book in outline form with the layout in two columns: one column is a step by step procedure of the operation and the other column lists instruments and sutures used in each step. The technique of most operations is well illustrated; also the group illustrations of instruments used in various operations are excellent. The name of each instrument could better have been under the instrument rather than numbers, which require reference to footnote. In the chapter on blood transfusions it is unfortunate that a word of caution is not given to as every safeguard to avoid giving incompatible blood.

A bibliography would be of great value in a book of this type. While every hospital should develop a procedure book of its own, this is a basically sound work for reference and guide for the preparation of such individualized procedure books.

KARL Q. LATIMER

**A**N excellent view of the work of the Johns Hopkins Clinic is presented in *Gynecology with Section on Female Urology* by Lawrence R. Wharton. The author emphasizes the fact that gynecology is no longer an exclusively surgical specialty but that the successful practitioner of gynecology must have an acquaintance with medicine, endocrinology, pelvic pathology and chemotherapy. The first two chapters deal with regional anatomy, the next two with embryology and congenital malformations.

Section III which embraces 3 chapters, discusses physiology and functional disturbances. These are well handled and the rational attitude of the author toward the question of endocrine therapy is commendable. The discussion of these subjects is excellent and may be read with profit and interest by the experienced gynecologist as well as by the beginner.

The section devoted to uterine and vaginal prolapse presents these matters clearly and is in accord with the best gynecologic thought of today. The illustrations are clear and help materially in giving clear understanding of the procedures which are described to one who may not have had large operative experience. Only those procedures are included which are favored by the weight of gynecologic opinion. It is pleasing to find, under the heading of retrodisplacement a reminder that wholly symptomless movable retrodisplacements may need no treatment.

THE MANUAL OF OXYGEN THERAPY TECHNIQUES, INCLUDING CARBON DIOXIDE, HELIUM, AND HYPERBARIC. By ALBERT H. ANDREWS, JR. W. D. CHAMBERLAIN, The Year Book Publishers, Inc. 612  
OPERATING ROOM TECHNIQUES By Elyse Louise Alexander, R.N. 24 Lane The C. Mosby Co. 643

GYNCOLOGY WITH A SECTION ON FEMALE UROLOGY By LAWRENCE R. WHARTON, Ph.D. M.D. Philadelphia: Saunders Co. 1941

fero  
sacr  
displacement, is stressed  
The sections on inflammatory diseases, diseases of the vulva, and infections and tumors of the cervix are well done

Among the readers of the section on hysterectomy there may be a difference of opinion concerning the advisability of cauterization of the cervix in cases in which subtotal hysterectomy is to be done immediately. The fastening of the broad and round ligament stumps to the stump of the cervix, thereby limiting the mobility of the ovaries and removing them from their normal location in the lateral fossae of the pelvis, will not meet the approval of all gynecologists. There are excellent chapters on tubal disease, tumors of the ovaries, endometriosis and sterility. The section on female urology adds a feature not usually found in texts devoted to gynecology. Commenting from the Johns Hopkins Clinic, in which female urology has been so highly developed, it seems appropriate that this section should be included. An excellent review of the urologic field as applied to women is given and the material found here will be of use to many readers who wish a concise discussion of the urologic diseases in female patients together with suggestions as to the most efficient management. The Kelly method of cystoscopy is the only one illustrated. The author shares the preference of the clinic in which he works for this method.

The illustrations throughout are excellent. The reviewer and this will be true of many of the older readers of the book, finds many old friends among the illustrations. A large number of the older drawings of Max Brödel, which had previously appeared in the works of Kelly and Cullen, are used. This is no criticism for the illustrations of Brödel have never been surpassed, and there seems no good reason, when drawings as good as these are available, they should not be used. New illustrations by Miss Eliza Brödel and Leon Schlossberg, another of Brödel's pupils, are also very good.

The book is an excellent one. It seems rather better adapted to the practitioner, resident or intern, than to the undergraduate but will find a wide field of usefulness. One minor point may be mentioned. There appears a reference to Sir John Hunter. Although Hunter deserved any honor which might have been given him he never achieved knighthood or a baronetcy and remained plain John Hunter to the end of his days.

The publishers have done a workmanlike job and produced a book with sturdy binding, good paper, clear print, and excellent illustrations.

The book may be commended to those who desire a concise and accurate account of the present status of gynecology.

W. C. DAYFORTH

In the work of the Argentine author, Lelio Zeno, there are no minute descriptions of more or less well known operations but there is an endeavor to lay down a number of principles to guide the surgeon with a fundamental knowledge of the subject of plastic surgery. There are several chapters on subjects of a general character which are, in our opinion, the most important of the book. These concern the study of surgical processes, such as wounds, burns, septic wounds, and scars, in which the plastic surgeon can intervene successfully in order to prevent malformations and morphological disturbances. The therapeutic ideas endorsed are based upon respect for the reparative forces already existing in the patient. Biological treatment stresses the importance of rest, complete immobilization of the affected parts in a functional position, drainage, and methods of improving the return circulation.

The chapter on burns is important because the principles of the biological treatment are laid down. Immobilization by direct plaster of paris covering of the burned surface is advised. Many examples illustrate the treatment advised which coincides in some respects with that recommended by those who are studying this problem at the present time. The chapters on grafts—bone, skin, fat, aponeurotic—are based upon recent surgical experience as well as on the dicta of modern biology. The author's discussion is illustrated with operative sketches and descriptions of cases.

This work fills a definite gap in the medical literature of our South American republics.

HÉCTOR MARINO

THE timely and profusely illustrated monograph, *Skin Grafting of Burns*,<sup>2</sup> deserves a place in the working library of every surgeon responsible for the care of patients with severe burns. One has only to study a few of the illustrations picturing the results obtained in cases of severe contracture or of cases of extensive burns with long delayed healing to realize that the authors "know where they speak" and have attained a degree of perfection in performance that represents the best in American surgery. Results such as they have depicted can be attained only by long and arduous devotion to the task of solving difficult surgical problems, the willingness to accept difficult cases after others have failed and the determination to bring them to a successful conclusion by patient perseverance and skillful specialized surgical care.

With war again bringing to the surgeon unprecedented numbers of patients with severe burns it is inevitable that men with little previous experience in the care of burns should be confronted with such cases in increasing numbers and should grope for new and better methods of treatment. The resulting confusion of ideas has been well set forth in the open ing "Note to the Reader," in Chapter 3 on "Early Local Care" and in Chapter 16 on "Treatment of Burns in World War II." In the praiseworthy effort to evaluate the new methods that have been de-

*SKIN GRAFTING OF BURNS. PRIMARY CARE, TREATMENT, REPAIR.*  
By JAMES BARRETT BROWN, M.D., and FRANK MCDONOUGH, M.D.  
Phila., London and Montreal: J. B. Lippincott Co. 1943.

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

**A**n excellent manual on oxygen therapy technique *Manual of Oxygen Therapy Techniques* by Albert H. Andrews, describes briefly but clearly the various accepted methods of oxygen administration, namely tent, catheter and mask together with the slight differences in technique required to use efficiently the different types made by the various manufacturers.

The author also summarizes the effectiveness of the various methods in table headed Factors Affecting Choice of Administrative Methods which, as he states, reveals that "single method of administration can entirely replace either or both of the other methods."

The book should be available to all those concerned in the administration of oxygen therapy.

WALTER M. BOOVER

**T**HE excellent volume *Operating Room Techniques* is for nurses and will be of great value to students, graduate nurses, and operating room supervisors. The make-up of the book is well planned, the type is legible, the pages large for easy reference and the paper of good quality. The book is profusely illustrated but it is unfortunate that more sequence photographs, such as the first three in Chapter V, are not used.

The first third of the volume is devoted to operating room fundamentals of which the chapters on personnel of the operating room, standardization of duties, and precautions are unusually good. The portion of Chapter VIII pertaining to description of outfit is not in agreement with the recent literature nor is any mention made of cotton as suture material. The chapter on sterilization should be more complete for example no mention is made of rinsing catheters after being sterilized in formaldehyde. Likewise no illustration or description is given of sponges, laparotomy pads, laparotomy sheets, etc. etc., as to size, how made and folded. The chapter on draping the patient is excellent. Unfortunately the photographs infer the nurses should drape the patient. The chapter and illustrations on surgical positions are excellent but the illustration of the positions might better precede each set of operations. A section with appropriate illustrations pertaining to hand signals for forceps, scissors, sutures, ligatures, knife and syringe would be of great aid. Also a para-

graph on how to pass instruments, sutures, and ligatures should have been included.

The last two-thirds of this work is procedure book in outline form with the layout in two columns one column is a step by step procedure of the operation and the other column lists instruments and sutures used in each step. The technique of most operations is well illustrated also the group illustrations of instruments used in various operations are excellent. The name of each instrument could better have been under the instrument rather than numbers, which require reference to a footnote. In the chapter on blood transfusions it is unfortunate that word of caution is not given to use every safeguard to avoid giving incompatible blood.

A bibliography would be of great value in a book of this type. While every hospital should develop procedure book of its own, this is a basically sound work for reference and guide for the preparation of such individualized procedure books.

EARL Q. LATIMER

**A**N excellent view of the work of the Johns Hopkins Clinic is presented in *Gynecology with Section on Female Urology* by Lawrence R. Wharton. The author emphasizes the fact that gynecology is no longer an exclusively surgical specialty but that the successful practitioner of gynecology must have an acquaintance with medicine, endocrinology, pelvic pathology and chemotherapy. The first 11 chapters deal with regional anatomy, the next two with embryology and congenital malformations.

Section III which embraces 3 chapters, discusses physiology and functional disturbances. These are well handled and the rational attitude of the author toward the question of endocrine therapy is to be commended. The discussion of these subjects is excellent and may be read with profit and interest by the experienced gynecologist as well as by the beginner.

The section devoted to uterine and vaginal prolapse presents these matters clearly and in accord with the best gynecologic thought of today. The illustrations are clear and help materially in giving clear understanding of the procedures which are described to one who may or have had large operative experience. Only those procedures are included which are favored by the "right of gynecologic opinion." It is pleasant to find, under the heading of retrodisplacement, reminder that wholly asymptomatic less movable retrodisplacements may need no later

MANUAL OF OXYGEN THERAPY TECHNIQUES, INCLUDING CURRENT  
INSTRUMENTS, MASKS, AND TENTS. BY ALBERT H. ANDREWS, JR.  
M.D. CHICAGO: THE YEAR BOOK PUBLISHERS, INC. 1943.  
OPERATING ROOM TECHNIQUE. BY LEONIE LEE and GLENNER R.  
McLENNAN. THE C. C. Mosby Co. 1943.

GYNCOLOGY WITH SECTION ON FEMALE UROLOGY. BY LAWRENCE  
WHARTON, F.R.C.S. & M.D. Philadelphia: Saunders Co. 1944.

B Magnuson is excellent. It points out clearly the importance of the necessary preparation of the patient for treatment, describes the types of operations that may be used and the advantages and disadvantages of each. A chapter is devoted to the special considerations of various regions and there are illustrations of anatomical approaches and diagrams of several operations.

Presumably patients with ununited fractures will be evacuated to large general hospitals, where surgeons experienced in this kind of work will be available. In any event, it is hoped that it will be necessary for the surgeon who is to do a bone grafting operation with a motor saw to obtain his experience by practicing on a bone from the kitchen, as is suggested by Dr. Magnuson.

Dr. Arthur Davis draws upon his large experience in the treatment of fractures of the spine for a very detailed description of the management of fractures and dislocations in each region of the column. The descriptions of various techniques are quite clear and should be very helpful to those who have not dealt with many of these injuries.

The best section, in the opinion of the reviewer, is that on the treatment of compound fractures by J. Albert Key. The subject is thoroughly covered and the article gives the impression that it was written especially for the military surgeon with the various exigencies of this type of practice in mind. On the other hand, the part of the book which deals with osteomyelitis, also contributed by Key, has little bearing upon military surgery. It is devoted largely to a discussion of hematogenous osteomyelitis, a disease of childhood, uncommon in adults, and rare in military practice. It was written for a treatise on surgery and could well have been omitted from this manual, especially since the type of bone infection commonly arising from war wounds is dealt with in the sections on ununited and compound fractures. Although the committee which prepared this book made no pretense of covering the entire subject of military orthopedics, one wonders whether they might not have added to its usefulness by including chapters on the transportation of fracture cases and on amputations.

A. DEF SMITH.

THE little monograph by James entitled *Regional Analgesia for Intra-Abdominal Surgery*<sup>1</sup> outlines a technique of regional analgesia which the author claims should be widely applicable in abdominal surgery, particularly in the war wounded, when the use of general or spinal anesthesia may be contraindicated. His method consists of a bilateral intercostal block of the 6th to 12th thoracic nerves, supplemented by a posterior splanchnic block, and finally by infiltration of the line of incision. Adequate preliminary medication, gentle operative technique, careful psychological management, and supplementary use of oxygen or intravenous pentothal with

<sup>1</sup>REGIONAL ANALGESIA FOR INTRA-ABDOMINAL SURGERY WITH SPECIAL REFERENCE TO ANESTHETIC HYDROCHLORIDE. By Norman R. James, L.R.C.P. & S. (Ed.) D.A. (R.C.P. & S. Eng.) London J & A. Churchill Ltd 1943

inhalation of nitrous oxide-oxygen when indicated are emphasized in detail.

The unusual feature is the long duration of analgesia—three hours—and freedom from toxic effects with an agent known in this country as "pontocaine," hitherto reserved largely for spinal and topical anesthesia. The author is not specific as to the number of cases or the duration of his experience, but his favorable report justifies trial of pontocaine in a wider variety of regional nerve blocks. Since the method requires technical skill and is time consuming, it will probably not receive wide application in the gravely war wounded, where the need for minimization of shock justifies its trial.

HUGH O. BROWN

THE fundamentals of obstetrics are presented in logical fashion in Beck's *Obstetrical Practice*<sup>2</sup>. Beginning with the development of the ovary and the ovum and correlating this with the changes in the endometrium during the menstrual cycle, Beck points out the hormonal influences that bring about these physical changes.

The development of the fetus and its placenta and membranes is clearly described and adequately illustrated, and the physiological activity of the placenta is thoroughly explained. A discussion of the associated physiology of the fetus naturally follows. The anatomical and physiological changes seen in pregnant women and studies of all of the systems and metabolism are covered adequately.

The diagnosis and management of pregnancy are clearly set forth. Outlines for physical examination and a dietary chart giving the nutritional value of various foods may be of considerable use and value to the general practitioner, especially to those doing deliveries at home or in hospitals in which dietary problems receive scant attention. The anatomy and dynamics of labor are well presented including the mechanism of labor in the various presentations and positions and in the first, second, and third stages of labor. The clinical course of labor and the management of the first, second, and third stages of labor are clearly set forth. Pelvimetry is reviewed and the importance of this aid to the diagnosis of potential complications is pointed out. The puerperium, postpartum care, and complications are well described and lactation is well covered.

It is in the clinical subjects that this book best reflects the experience and wisdom of the author. Abortion and ectopic pregnancy are described by a writer obviously of large experience, keen observation, and a willingness to accept workable suggestions from others. The toxemias, early and late, are well described and the treatment outlined is simple, direct, and effective. An unusual amount of space is devoted to medical and surgical complications of pregnancy and the pathology of labor. Pelvic deformities and their effect on labor are handled according to the older classification of de

<sup>2</sup>OBSTETRICAL PRACTICE. By Alfred C. Beck M.D. 3d ed. Baltimore The Williams & Wilkins Co 1942





# AMERICAN COLLEGE OF SURGEONS

## HONORARY FELLOWSHIPS CONFERRED ON DISTINGUISHED RUSSIAN SURGEONS

**H**ONORARY fellowships in the American College of Surgeons were conferred in Moscow on July 15 upon two distinguished Russian surgeons Dr Nicolai N Burdenko, director of the Operative Surgery Institute, Moscow University, and Surgeon General of the Russian Army, and Dr Sergei S Yudin, surgeon in chief, Surgical Clinic of the Institute Sklifassovski, Central Emergency Hospital, Moscow, and director of the Surgical Clinic, Postgraduate Medical School.

The fellowships were conferred, under authorization of the Board of Regents, by Colonel Elliott C Cutler and Lieutenant Colonel Loyal Davis of the Medical Corps, United States Army, during the recent official visit to Russia of the Anglo-American Surgical Mission. Among the other members of the mission were Surgeon Rear Admiral Gordon Gordon-Taylor, Major General D C Monro, professor of military surgery at the Royal Army Medical College, Millbank, Mr E Rock Carling, and Mr R Watson-Jones, all of England, and Dr W G Penfield, professor of neurology and neurosurgery at McGill University, Montreal.

The purposes of the surgical mission were to study the results of war surgery and to explore the possibilities of extending medical relationships between the allied countries. Colonels Cutler and Davis reported a very unusual, valuable, and interesting experience. The fellowships were conferred during an impressive ceremony in the presence of the Commissar of Public Health and of the senior representatives of the Army, Navy, and other medical activities.

### PRESENTATION OF CANDIDATES AND CONFERRING OF FELLOWSHIPS

"This gathering is momentous. We doctors now signify to the solidarity and common purpose of a majority of living peoples. The occasion justifies the hope that this junction of our races is but the beginning of a friendly and co-operative union for all time. As a token of this spiritual union Colonel Davis and I are empowered to grant honorary fellowships in the American College of Sur-

geons to two distinguished Russian surgeons, a function which heretofore has never occurred beyond the confines of our own country.

"By virtue of the authority vested, by the Board of Regents of the American College of Surgeons, in this Commission consisting of Colonel Cutler, professor of surgery, Harvard University, and Colonel Davis, professor of surgery, Northwestern University, we now declare that you, Nicolai Nilovic Burdenko, are hereby admitted to the honorary fellowship of the American College of Surgeons and may forever indulge in all the rights and privileges of that body of surgeons.

"By virtue of the authority vested, by the Board of Regents of the American College of Surgeons, in this Commission consisting of Colonel Cutler, professor of surgery, Harvard University, and Colonel Davis, professor of surgery, Northwestern University, we now declare that you, Sergei S Yudin, are hereby admitted to the honorary fellowship of the American College of Surgeons and may forever indulge in all the rights and privileges of that body of surgeons.

"We congratulate ourselves that in this tumultuous world men of such eminence have found in service to the State a way of life that brings satisfaction to all."

For the Board of Regents of the American College of Surgeons

ELLIOTT C CUTLER  
Professor of Surgery, Harvard University, Chief Consultant in Surgery, U S Army, European Theater of Operations

LOYAL DAVIS  
Professor of Surgery, Northwestern University, Senior Consultant in Neurological Surgery, U S Army, European Theater of Operations

### RESPONSE BY ACADEMICIAN BURDENKO

"I am deeply moved by the honor of electing me a member of the American College of Surgeons. I understand this honor as a generous approval of my papers and my work in the past and present. It makes me think about my work in the future, particularly now when the fight against fascists has reached a decisive stage.

formed pelvis, although the Caldwell-McLoy claval fixation is well reviewed.

Hemorrhages are discussed clearly and conservative treatment in placenta previa is indicated. Cesarean section is given its proper place in the treatment of placenta previa, the operation of choice in the central type, in elderly primiparae, and in those in whom there is limited cervical dilatation.

The discussion of puerperal infection is thorough and the recommendations for treatment are sound.

The majority of obstetrical operations are well covered, the rather profusely illustrated section on operative obstetrics. Forceps, version and cesarean section are fully covered, and clear conception is given to the student regarding the contraindications and dangers as well as the advantages of the various procedures.

In general, this is a sound book, carefully worked out by an excellent practical clinician whose advice may well be followed by the great majority of practicing obstetricians. **FREDERICK H. FALLS.**

THE eighth edition of *The Principles and Practice of Obstetrics*—a book that has been in use for 3 years, in itself attests the quality of the book. It is particularly fortunate that this valuable textbook is to be kept up-to-date and in daily use, and that Dr. Greenhill is the one to do it. His long association with Dr. DeLee is assurance that Dr. DeLee's teachings will be continued.

THE PRINCIPLES AND PRACTICE OF OBSTETRICS. By Joseph B. DeLee, A.M., M.D., and J. F. Greenhill, B.S., M.D. 8th ed., Philadelphia and London, W. B. Saunders Co. 943.

In the first place the publisher has maintained their usual high standards in this book. The binding is attractive, the type clear and the illustrations are clearly reproduced. The only exceptions that are noted are a few photographs of operative procedures—notably the illustrations of the Waters technique of extraperitoneal cesarean section. In this last see the original photographs are probably not clear—photographs of operations rarely are. This however is not criticism of the publisher's work.

The arrangement of the book is essentially the same as in previous editions, and is clear. The Index is detailed and adequate. The author has also provided a satisfactory bibliography at the end of each chapter for further reference and study.

The junior author has done an excellent piece of work in bringing this book up-to-date. This applies particularly to the sections that deal with physiology, embryology, endocrinology and chemotherapy. Diagrams are used to present certain problems in a simple manner. The standard techniques of conducting normal labor and the difficult problems that complicate labor and pregnancy are sensibly discussed. A little more space might have been devoted to the uterine complications of pregnancy and the puerperium, but that does not imply neglect even of that subject. The chapters on puerperal infection, extruterine pregnancy, abortion, uterine malplacements, and pelvic tumors in pregnancy are especially good. All in all, this is an excellent book, and Dr. Greenhill is to be commended for his service to the profession in keeping it up-to-date.

LAURENCE R. WATSON.

## BOOKS RECEIVED

Books received are acknowledged in this department and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

APPLIED ANATOMY OF THE HEAD AND NECK, FOR STUDENTS AND PRACTITIONERS OF DENTISTRY. By Harry H. Shapiro, D.M.D. Philadelphia, London and Montreal J. B. Lippincott Co. 945.

THE MECHANICS OF OBSTETRICS. By Lucius W. Voss, M.D. and Mario A. Cardillo, A.B. M.D. F.A.C.S. Philadelphia F. A. Davis Co. 943.

KINETIC BIOLOGY INCLUDING SPERMIOLOGY AND PROTECTIVE DRESSINGS THE KINETIC METHOD OF VISCAL

TACHING. By Seymour W. Meyer, B.S., M.S., M.D. Philadelphia F. A. Davis Co. 943.

RECONSTRUCTIVE SURGERY OF THE EYE. By Wendell L. Hughes, M.D. F.A.C.S. St. Louis The C. V. Mosby Co. 943.

BLACK SURGERY. By Gordon S. Searles, Lt. Col. M.C. U.S.A. New York W. B. Norton & Co. Inc. 943.

HYPERTENSION. A MANUAL FOR PRACTICE. THE BLACK BLOOD PRESSURE. By Irvine H. Page, A.B., M.D. Springfield, Ill. Charles C. Thomas, 943.

PHYSIOLOGY OF THE NERVOUS SYSTEM. By Jakob Fajzler, F.R.S., M.B., D.Phil., D.Sc. (Oxon.), F.R.C.S. (Edin.) and ed. London, New York, and Toronto Oxford University Press. 943.

his brilliant experimental work, his elaboration of the basic principles of a new type of field surgery, which has proved so brilliantly successful in the present war, make us certain that he will be a worthy member of the glorious family of the finest representatives of contemporary surgery that is combined in the Royal College of Surgeons and American College of Surgeons. Professor Yudin will bear the title of Fellow of the College with equal honor and worthiness. His name is tied with great successes in abdominal surgery, in plastic operations on the alimentary tract, in blood transfusion, and in the prophylaxis and treatment of infected wounds, etc.

"We, the representatives of the family of Soviet medical workers, are today justifiably proud of the great honor bestowed on Academician Burdenko and Professor Yudin. At the same time we express our sincerest appreciation to the Royal College of Surgeons of England and to the Ameri-

can College for this mark of distinction. In the name of the People's Commissar and in our name I ask you, Mr. Vice-President and Colonel Cutler to convey our thanks to your organizations. In the name of the People's Commissar and in our name I congratulate Academician Burdenko and Professor Yudin on their selection for the honorary fellowship of the Colleges.

"Today's occasion takes place in days of bitter warfare against the cruel enemy of Progressiveness—Hitler's Fascism! In this war, our medical teaching has extensively become the teaching of War Medicine, and it helps our armies in their struggle against this cruel foe. The admission of the most famous Soviet scientists to Honorary Fellowship of the Colleges marks in itself a strengthening of the scientific ties between the allied nations. I am certain those ties will strengthen further in the continuation of this struggle to complete victory over our common enemy."

---

## CLINICAL CONGRESS NOT TO CONVENE IN 1943

THE annual Clinical Congress of the American College of Surgeons will not convene in 1943.

Motivated primarily by patriotism, in arriving at their decision the Regents were influenced by the present conditions surrounding the general war program which have led to a greater burden on the members of the surgical profession in their local communities as a result of the large proportion of the profession which is serving with the armed forces. The Regents by this action took cognizance of the desire of the profession to do nothing which would interfere with the successful prosecution of the war program such as would be caused by temporary absence of its members from civilian duties during the Congress, embarrassment of the transportation system, and interference with the work of a local profession in preparations and presentations incident to such a meeting.

At the annual meeting of the Board of Regents which will be held later in the year, fellowship in the College will be conferred *in absentia* on the class of initiates of 1943, as there will be no convocation exercises. At the same time the list of hospitals, cancer clinics, medical services in industry, hospitals conducting programs of graduate training in surgery, and medical motion pictures, that meet the College standards, will be approved and later published.

All present officers, Regents, Governors, and standing committees will continue in office during the ensuing year.

The International Society of Surgery (now confined to the Western Hemisphere) which was to have met in special session during the 1943 Clinical Congress, under the presidency of Professor José Arce, of Buenos Aires, has also cancelled its meeting.

I recognize this election to be of deep and wide meaning.

"The last decade has shown that the United States is now the center of medical science and scientific problems are to be solved from the point of view of American science.

"During this year I have received very many proofs of attention from the United States. My contributions to world science and field surgery are but modest. It pleases me to share this great honor with all surgeons of my country."

#### RESPONSE OF PROFESSOR YUDIN

"You will easily understand my animation when immediately after one high honor the surgeons of a second great Allied country—U.S.A.—bestow on me another one.

"I know a little of your beautiful country. I am proud of my personal acquaintance—and even friendship—with George Cline, Howard Kelly, the late Mayo brothers and some other American surgeons of world fame.

But could I dream 15 years ago that time would come when I should not only become an Honorary Fellow of the American College of Surgeons, but also should receive my degree and this diploma from the hands of the great Harvey Cushing's successor.

By the way it is an astonishing fact that the day of my decoration by the Allies completely coincides with the day I was severely wounded by a German shell on the eve of July 15, 1915.

For the second time in the same quarter of a century our nations are united in their hard efforts to save their countries and the world a civilization. Now just as it was for the first time we are fighting with the same eternal dangerous enemy—Germany. But as it was on the first occasion our British Allies are fighting again on our side.

"Victory will be ours. Nobody has any doubts about it, even our enemies. Let our scientific relations which have begun in time of such strained military needs, get stronger and flourish more and more after this victory and the won peace.

"In a time of struggle surgery is as necessary for victory as arms, transports and all kinds of supplies. But when the last gun of enemy will cease and the released humanity will turn with hope to the restoration of great destruction caused by the war we surgeons will have to heal the wounds and injuries of hundreds of thousands of people who have won for us this victory.

Your high election of me as Honorary Fellow of the American College of Surgeons will serve as a new additional stimulus for further develop-

ment of my scientific work in surgery which has already received from you such high estimation. I once more deeply and sincerely thank you.

Honorary fellowships in the Royal College of Surgeons of England were conferred by the British delegates just prior to the awarding of the honorary fellowships in the American College of Surgeons.

#### ADDRESS BY VICE-COMMISSAR KOLEMIKOFF

After the presentation of the fellowships, Vice Commissar Kolemnikoff thanked the representatives of the two Colleges.

Mr. Vice President, Colonel Cutler and all those present. The admission today of two outstanding Russian surgeons, Academician Burdenko and Professor Yudin to the Honorary Fellowship of the Royal College of Surgeons of England presents itself to us, witnesses of this act, as an occasion of great cultural and political meaning.

"The Royal College of Surgeons of England since long ago has been famed as an organization, responsible in no small way for the development of surgery both in England and outside her boundaries. Amongst the fellows of this College have been, and are now some of the outstanding representatives of English surgical thought. The greatest exponents of surgery of their countries have earned the honor of being honorary fellows of this College since its creation in accordance with its established and glorious traditions. On every occasion the selection of honorary fellows amongst foreign scientists has been an unbiased and just appreciation of their really great technical contributions. Therefore, selection to a honorary fellowship of the Royal College of Surgeons of England, has always been a distinction in the eyes of the world's scholars. Similarly the glory of the American College of Surgeons is well known.

"We are glad in the knowledge that today the choice of the Royal College of Surgeons and the American College of Surgeons should have fallen on the two best representatives of our native surgery. Both the new honorary fellows of the Colleges, Academician Burdenko and Professor Yudin, are deservedly famed in our country and outside her boundaries, as leading experts in the realm of their specialties. Not for nothing are they both worthy of highest scientific decoration of our country—the Stalin Prize whilst Academician Burdenko with honor holds the title of Hero of Socialist Work.

"The outstanding contributions of Academician Burdenko in the development of neurosurgery



## A TRIBUTE TO THE DOCTORS OF NORTH AMERICA

THE American College of Surgeons has received through the Division of Cultural Relations of the United States Department of State a photostatic copy of a parchment presented to the American Ambassador in Brazil by the Brazilian Medical Associations of Rio de Janeiro on the occasion of Independence Day in the United States, which, as translated, reads as follows:

## INDEPENDENCE DAY

The Medical Associations of Rio de Janeiro, through their Presidents, send to the grand statesman, Franklin D. Roosevelt, on this date, and through the medium of the worthy Ambassador Caffery manifestations of fellowship which their Brazilian colleagues, inspired by the best sentiments of Pan-Americanism, send in tribute to the North American doctors.

Academia Nacional de Medicina, Prof. Dr. Joaquim Moreira, da Fonseca.  
 Academia Brasileira de Medicina Militar, Coronel Dr. Florêncio de Abreu.  
 Colegio Brasileiro de Cirurgiões, Dr. Oscar Alves.  
 Sindicato dos Médicos do Rio de Janeiro, Dr. Alvaro T. Vares de Souza.  
 Sociedade dos Ex Internos dos Hospitais Militares, Prof. Dr. Estelita Lima.  
 Sociedade Brasileira de Dermatologia e Sifilografia, Prof. Dr. Joaquim Motta.  
 Sociedade Brasileira de Gastroenterologia e Nutrição, Prof. Dr. Augusto Brasilho Filho.

Sociedade de Ginecologia e Obstetrícia do Brasil, Dr. Jorge Sant'Anna.  
 Sociedade Brasileira de Oftalmologia, Dr. Ruy Robm.  
 Sociedade Brasileira de Pediatria, Dr. Cesar Fereira.  
 Sociedade Brasileira de Tuberculose, Dr. Alberto Rezza.  
 Sociedade Brasileira de Urologia, Prof. Dr. Alvares Cam-pido de Sant'Anna.  
 Rio de Janeiro July 4, 1943.

## RESPONSE BY THE BOARD OF REGENTS

The following response on behalf of the Board of Regents of the American College of Surgeons is being transmitted to the Medical Associations of Rio de Janeiro through official governmental channels:

"The officers and members of the Board of Regents of the American College of Surgeons extend their grateful thanks to the Medical Associations of Rio de Janeiro for the expressions of solidarity which they have extended to their colleagues in the United States through the medium of the United States Ambassador to Brazil. It is the earnest desire of the Regents that their friends in Rio de Janeiro should appreciate that this same spirit of brotherhood is felt no less keenly in the United States.

"There is every assurance that the alliance which has been formed between Brazil and the allied nations will more speedily and certainly bring about the victory for right and for justice."

# SURGERY

## GYNECOLOGY AND OBSTETRICS

*An International Magazine, Published Monthly*

VOLUME 77

NOVEMBER, 1943

NUMBER 5

### THE VALUE OF THE VAGINAL SMEAR IN THE DIAGNOSIS OF UTERINE CANCER

JOE VINCENT MEIGS, M D, F A C S, RUTH M GRAHAM, B S, MAURICE FREMONT-SMITH, M D, F A C P, ISRAEL KAPNICK, M D, and RULON W RAWSON, M D, Boston, Massachusetts

CANCER of the cervix and body of the uterus is a curable condition (1, 8) Early diagnosis and treatment are prerequisites for cure Bigelow and Lombard say that in certain forms of cancer the chance of cure decreases 4 per cent a week Approximately the same statement is given for carcinoma of the cervix by Todd who reports that from the onset of abnormal bleeding the chance of cure decreases 3 34 per cent a week The average time from the onset of symptoms to operation is stated to be 7 5 months (2, 7, 17) Eleven of a hundred women with cancer of the cervix reach the surgeon in

the early (operable) stage, 29 in the stage of so called "border-line operability", 60 are totally inoperable when treatment is begun (8)

Delay is thus responsible for a majority of deaths from cervical cancer, a delay to which both patient and physician contribute A patient with cancer of the cervix reports to her physician on the average 4 months after the onset of bleeding, from the patient's first visit another 4 months intervene before operation is performed Figures quoted by Simmons and Daland in 1924 and by Hoge in 1942 are almost identical as to preoperative time wasted

The critical weeks lost by the patient can be salvaged only by slow education of the public We are concerned here with the fact that the physician, confronted by early cancer of the cervix or endometrium, often fails to make a diagnosis during the only period when the life of the patient can be saved Ignorance, desire

From the Vincent Memorial Hospital (the Gynecologic Service of the Massachusetts General Hospital) the Poadville Hospital (Massachusetts Department of Public Health) and the Thyroid Laboratory of the Massachusetts General Hospital

From the Departments of Gynecology and Medicine of the Harvard Medical School

Aided by a Grant from the William T Miltoe Fund and Joseph H. Clark Bequest of Harvard University

#### *(Legends for frontispiece)*

First row, normal cells Reading from left to right normal precornified cell with basophilic cytoplasm and vesicular nucleus, normal fully cornified cell with acidophilic cytoplasm and pyknotic nucleus, normal basal cell with large vesicular nucleus (Magnification  $\times 875$ )

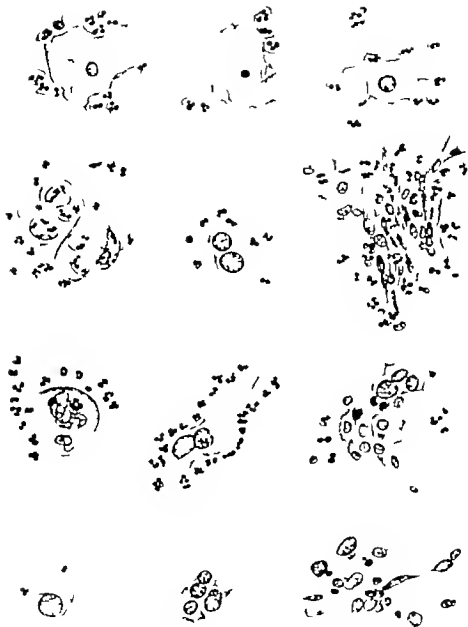
Second row, cells seen in carcinoma of the cervix Reading from left to right large atypical histiocytes with phagocytosed material and vacuoles, two cells with large nuclei (note especially size of nucleus in relation to size of cell), group of "fiber like" cells with elongated nuclei showing

considerable variation in size (Magnification  $\times 875$ )

Third row, cells seen in carcinoma of the cervix Reading from left to right large multinucleated giant cells, "tadpole" cell with double nucleus, group of atypical cells with variation in size and shape of nucleus (Magnification  $\times 875$ )

Fourth row, cells seen in carcinoma of the endometrium Reading from left to right large cell with large vesicular nucleus, group of abnormal cells with significant variation in size and shape of nucleus, atypical cells smeared from tumor in carcinoma of endometrium (Magnification  $\times 875$ )





The Values of the Symbols in the Diagrams of Uterine Contents — See General Notes  
 Ruth H. Graham, M. Sc. I. m. I. Smith, J. d. A. pack, and R. H. R. on

# SURGERY

## GYNECOLOGY AND OBSTETRICS

*An International Magazine, Published Monthly*

VOLUME 77

NOVEMBER, 1943

NUMBER 5

### THE VALUE OF THE VAGINAL SMEAR IN THE DIAGNOSIS OF UTERINE CANCER

JOE VINCENT MEIGS, M D, F A C S, RUTH M GRAHAM, B S, MAURICE FREMONT-SMITH, M D, F A C P, ISRAEL KAPNICK, M D, and RULON W RAWSON, M D, Boston, Massachusetts

CANCER of the cervix and body of the uterus is a curable condition (1, 8). Early diagnosis and treatment are prerequisites for cure. Bigelow and Lombard say that in certain forms of cancer the chance of cure decreases 4 per cent a week. Approximately the same statement is given for carcinoma of the cervix by Todd who reports that from the onset of abnormal bleeding the chance of cure decreases 3.34 per cent a week. The average time from the onset of symptoms to operation is stated to be 7.5 months (2, 7, 17). Eleven of a hundred women with cancer of the cervix reach the surgeon in

the early (operable) stage, 29 in the stage of so called "border-line operability", 60 are totally inoperable when treatment is begun (8).

Delay is thus responsible for a majority of deaths from cervical cancer, a delay to which both patient and physician contribute. A patient with cancer of the cervix reports to her physician on the average 4 months after the onset of bleeding, from the patient's first visit another 4 months intervene before operation is performed. Figures quoted by Simmons and Daland in 1924 and by Hoge in 1942 are almost identical as to preoperative time wasted.

The critical weeks lost by the patient can be salvaged only by slow education of the public. We are concerned here with the fact that the physician, confronted by early cancer of the cervix or endometrium, often fails to make a diagnosis during the only period when the life of the patient can be saved. Ignorance, desire

From the Vincent Memorial Hospital (the Gynecologic Service of the Massachusetts General Hospital), the Pondville Hospital (Massachusetts Department of Public Health) and the Thyroid Laboratory of the Massachusetts General Hospital.

From the Departments of Gynecology and Medicine of the Harvard Medical School.

Aided by a Grant from the William F. Milton Fund and Joseph H. Clark Bequest of Harvard University.

#### *(Legends for frontispiece)*

First row, normal cells. Reading from left to right: normal precornified cell with basophilic cytoplasm and vesicular nucleus, normal fully cornified cell with acidophilic cytoplasm and pyknotic nucleus, normal basal cell with large vesicular nucleus. (Magnification  $\times 875$ .)

Second row, cells seen in carcinoma of the cervix. Reading from left to right: large atypical histiocytes with phagocytosed material and vacuoles, two cells with large nuclei (note especially size of nucleus in relation to size of cell), group of "fiber like" cells with elongated nuclei show

ing considerable variation in size. (Magnification  $\times 875$ .)

Third row, cells seen in carcinoma of the cervix. Reading from left to right: large multinucleated giant cells, "tadpole" cell with double nucleus, group of atypical cells with variation in size and shape of nucleus. (Magnification  $\times 875$ .)

Fourth row, cells seen in carcinoma of the endometrium. Reading from left to right: large cell with large vesicular nucleus, group of abnormal cells with significant variation in size and shape of nucleus, atypical cells smeared from tumor in carcinoma of endometrium. (Magnification  $\times 875$ .)

to give reassurance unfamiliarity with pelvic examination reluctance to advise biopsy, ether examination and curettage all contribute to the critical delay. A technically simple method of making a presumptive diagnosis of uterine cancer in daily office practice would aid greatly in the early discovery of female genital malignancy. Such a method has been described by Papanicolaou (11 12 13) by which a diagnosis of uterine carcinoma may be made by examination of the vaginal smear. By suitable collection, fixing and staining of the vaginal secretion he has been able to identify cells present only in malignancy of the female genital tract.

In the belief that this work if corroborated places in the hands of the practitioner a practical method of early diagnosis, we have studied the vaginal smears taken from 220 patients.

#### MATERIAL

The material for this study comes from two sources: one the Vincent Memorial Wards of the Massachusetts General Hospital and the Gynecologic Tumor Clinic and the private practices of those associated with these two services; two the Gynecologic Service of the Pondville Hospital (Massachusetts Department of Public Health) and its Gynecologic and General Surgical Out Patient Clinics. One hundred and fifty-seven cases were taken from the Massachusetts General Clinic and 63 from the Pondville Hospital. These two sources are rich in material—the Massachusetts General Hospital having many gynecologic patients with nonmalignant lesions, and the Pondville Hospital having many with malignant lesions. The vaginal smears in all instances were taken by the authors themselves. Two of the authors, R. G. and I. K., made independent observations upon each slide of the Pondville series. In most cases the result of the biopsy was not known to either examiner. All smears were called either positive or negative, none "suspicious." It is noteworthy as an indication of the specificity of this method that in no instance was there disagreement between the two examiners.

#### TECHNIQUE

The technique for taking vaginal smears is that described by Papanicolaou (11). A slightly curved glass pipette 8 inches in length is at-

tached to a 3 inch rubber suction bulb. The pipette must be absolutely dry and the patient must not have douched the same day. These precautions are necessary since water in the vaginal smear destroys the cellular detail. The rubber bulb is compressed and the pipette is then inserted into the vagina as far as possible in order to reach the fornix. The bulb is released and the pipette withdrawn slowly. The material is blown on a previously marked slide which is immediately dropped into a bottle of fixative (one half ether and one half 95% alcohol). Since drying destroys cellular detail it is essential that the slide be placed immediately in the fixative. Fixation for 5 minutes is sufficient, but slides may be left in the fixative without deterioration for as long as 2 weeks.

The slides are run down through the alcohols (70%, 50%) to distilled water. They are stained for 3 minutes in Harris hematoxylin dipped four times in a 0.5 per cent solution of hydrochloric acid, washed in running tap water and placed in a 0.5 per cent solution of lithium carbonate for 1 minute. The slides are washed again in running tap water, rinsed in distilled water and run up through the alcohols (50%, 70%, 80%) to 95 per cent alcohol. They are then stained for 1 minute in a 0.5 per cent solution of orange G in 95 per cent alcohol. The smears are next washed in two changes of 95 per cent alcohol. They are stained in EA 36<sup>1</sup> for 2 minutes, washed in three changes of 95 per cent alcohol, run through absolute alcohol to xylol, and mounted in Canada balsam (10).

#### DIAGNOSTIC CRITERIA

To recognize the atypical cells found in carcinoma of the cervix and endometrium it is necessary at the outset to know the *normal cells* of the vaginal secretion. These normal cells may be divided into three groups: the cornified series, the basal cells, and the endometrial cells. Cornified cells are again divided in two groups, precornified and fully cornified. The precornified cells are large wafer-like cells with abundant thin green cytoplasm and a

EA 36 consists of  
 Light green ...  
 Eosin ...  
 Acid ...  
 Lithium carbonate ...

1% in 95% alcohol  
 1% in 95% alcohol  
 1% in 95% alcohol  
 1% in 95% alcohol

10 C.C.  
 100 grm  
 1000

vesicular nucleus (Fig 1) The fully cornified cells are similar to the precornified with the exception that the cytoplasm stains pink and the nucleus is pyknotic The cytoplasm may show some signs of degeneration such as wrinkling and granulation (Fig 1) Basal cells are smaller, round or oval cells with green cytoplasm and a vesicular nucleus (Fig 2) With extreme atrophy of the genital tract the nuclei of the normal basal cells may contain chromatin in large clumps Endometrial cells are the smallest of the normal cells They consist of a small vesicular nucleus with very little cytoplasm They show little variation in size and shape (Fig 3)

The criteria for the diagnosis of *carcinoma of the cervix* are as follows the cells show great variation in size, shape, and form — much greater variation than is usually seen in the pathological section of the same tumor The most striking variation in shape appears in the tremendously elongated “tadpole” cells (Fig 4), which have a rounded head containing the nucleus and a long thin tail Long fiber-like cells may be found (Fig 5) These cells are extremely elongated, with tapered ends, and contain an elongated nucleus, or two or three nuclei They may be found singly or in groups

Many atypical cells have vacuolated cytoplasm giving the cell a foamy appearance, but cellular vacuolization is not diagnostic of malignancy Staining characteristics of the cytoplasm are not diagnostic, since in the vaginal smear the atypical cells may have either basophilic or acidophilic cytoplasm This variation in staining may be due to differences in the acidity of the vagina as the result of either infection, parasitic infestation, or estrogen elaboration

The nuclei of abnormal cells show marked variation in shape and size, and bizarre forms occur There are often signs of increased activity of the nuclei, as indicated by clumping of the chromatin, granularity of the nucleus, and occasionally an apparent increase in the amount of nuclear material Nucleoli are seen occasionally but not consistently enough to make observation of the nucleolus an important aid in diagnosis Mitoses may occur but are very rare However, cells are seen which appear to be in a preliminary stage of mitosis

The most frequent variation of the nucleus is its size In the abnormal cell the nucleus often fills the entire cell, leaving a thin, but distinct rim of cytoplasm (Fig 6) Often multinucleated giant cells are seen, occasionally containing as many as a dozen nuclei (Fig 7)

Histiocytes are often present in positive smears (Fig 8) The histiocytes vary greatly in size They often contain phagocytosed cellular elements such as red blood cells, leucocytes, and cellular debris They frequently have acidophilic cytoplasm The histiocytes continue to show numerous vacuoles even after ingestion of cellular elements Histiocytes may appear in normal smears

Leucocytes are usually present, but their numbers vary tremendously In an occasional positive smear they appear in clumps

Red blood cells or evidence of old bleeding are present in every positive smear We have never made a diagnosis of malignancy without some evidence of blood The evidence of bleeding may be either red blood cells (which occasionally stain basophilic), fibrin, or old blood pigment, which appears as small orange or green, fern-like deposits

In the diagnosis of *endometrial cancer* the same general criteria apply evidence of blood must be present, an increase in leucocytes is usually seen, histiocytes are frequently found The variation in size of individual atypical cells in endometrial cancer is not so great as in cervical The cells are more like those seen in stained sections of the same tumor Abnormal endometrial cells are usually found in clumps which can be easily seen under low power These cells show very little cytoplasm and the nuclei are usually hyperchromic The chromatin may appear as dark granules in the nuclei The nuclei vary tremendously in size We have found that the diameter of normal endometrial nuclei varies between 3.7 micra and 9.4 micra The nuclei of tumor cells were found to measure 2.8 to 14.1 micra Haumeder found the nuclei of cells in carcinoma of the endometrium to be twice as large as those found in hyperplasia of the endometrium Occasionally in endometrial carcinoma large cells are seen with an abundant amount of cytoplasm and large vesicular nuclei (Fig 9), but are rare Mitoses (Fig 10) are very rare



Fig. Negative smear showing cornified and precornified cells, and 15 basal cells in lower left hand corner. Magnification  $\times 85$ .



Fig. Negative, tropic smear showing field of basal cells. Magnification  $\times 85$ .

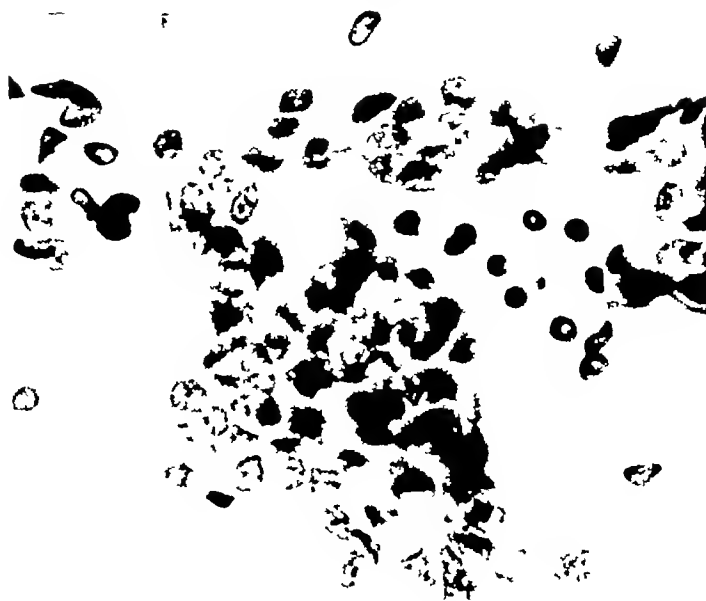


Fig 3 Smear taken from normal endometrium after surgical removal of the uterus Compare with Figure 12 Magnification  $\times 825$

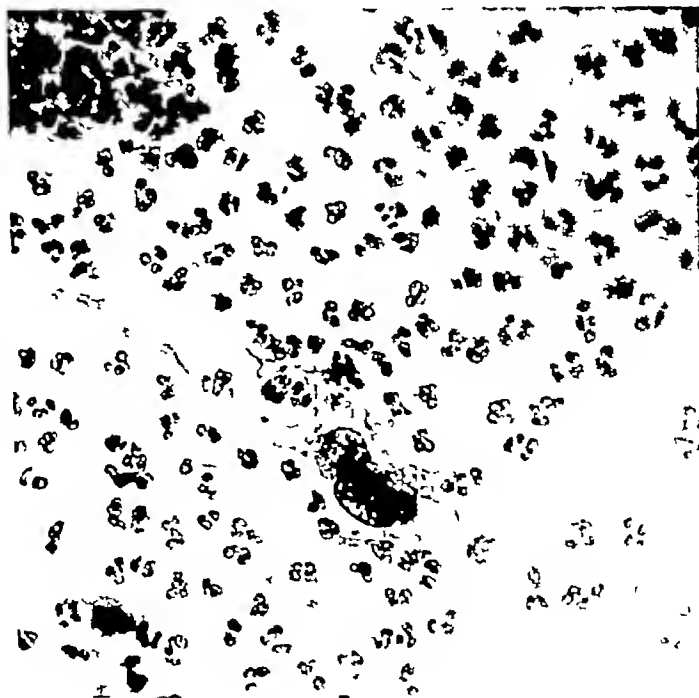


Fig 4 Carcinoma of the cervix A huge bizarre shaped cell with double nuclei illustrating the marked variation in size and shape of cells encountered in carcinoma of the cervix (Tadpole cell) Magnification  $\times 825$

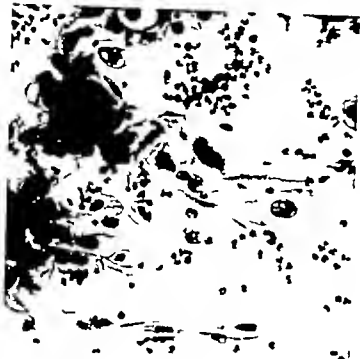


Fig. 5. A group of atypical cells seen in epidermoid cervical cancer. The long fiber-like cells in the lower portion of the photomicrograph are abnormal cells as counted frequently in positive scans. Magnification  $\times 8 \mu$ .

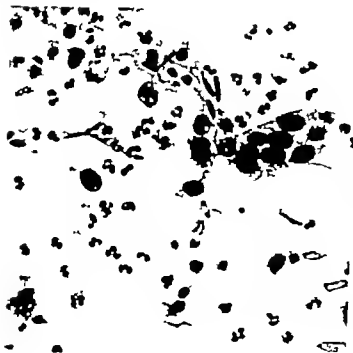


Fig. 6. Atypical cell group seen in epidermoid carcinoma of the cervix, illustrating the abnormal arrangement and shape of the nuclei. Magnification  $\times 8 \mu$ .

Fig 7 Two multinucleated giant cells seen in epidermoid carcinoma of the cervix Magnification  $\times 825$

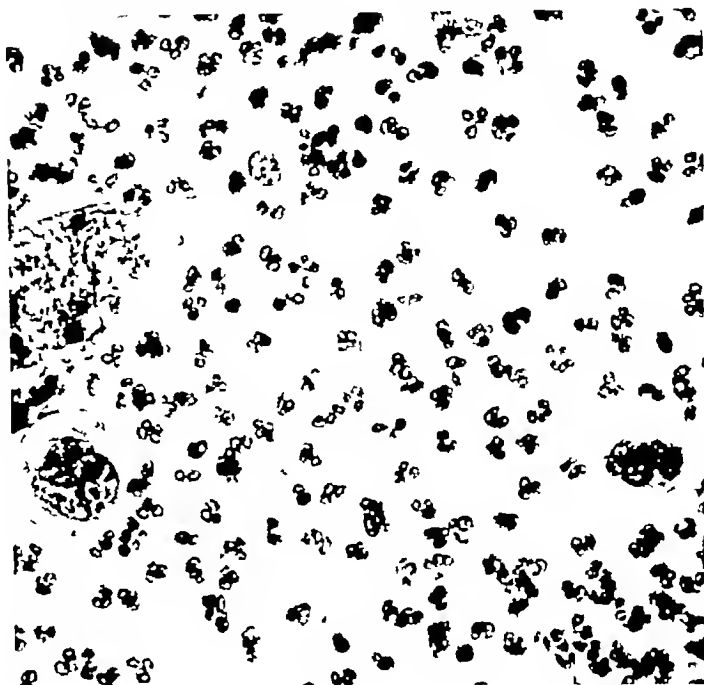
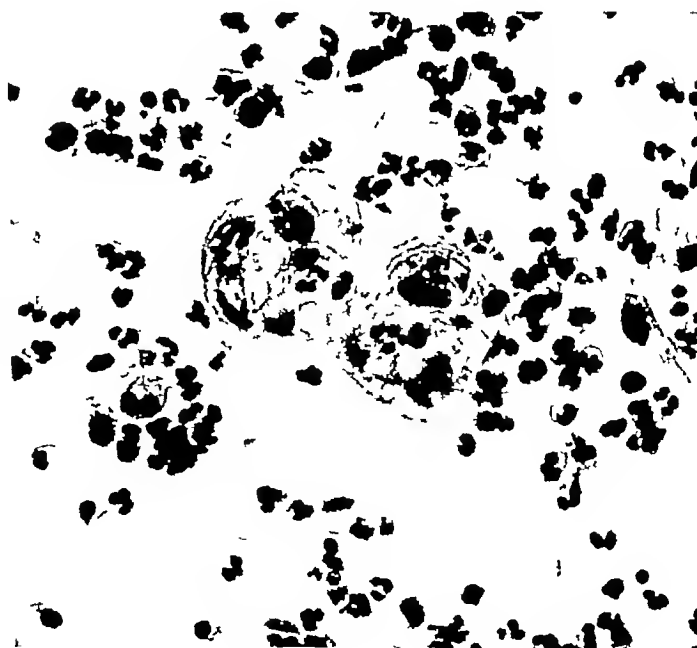


Fig 8 Two large histiocytes with phagocytosed polymorphonuclear leucocytes and red blood cells seen in a vaginal smear from a case of epidermoid cervical cancer Magnification  $\times 825$





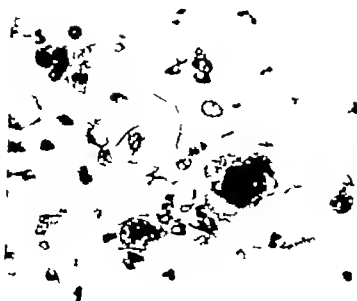


FIG. 9. Adenocarcinoma of the endometrium. Atypical large cells with large nucleolar nuclei—rare type of cell seen in endometrial carcinoma. Magnification  $\times 85$ .

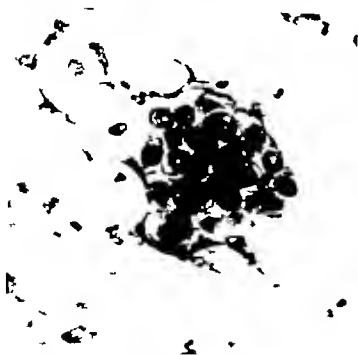


FIG. 10. Adenocarcinoma of the endometrium, group of cancer cells. One cell in mitosis. Magnification  $\times 85$ .

Fig 11 Adenocarcinoma of the endometrium Atypical cells showing great variation in size and vesicular nuclei with no apparent cytoplasm Vaginal smear Magnification  $\times 825$

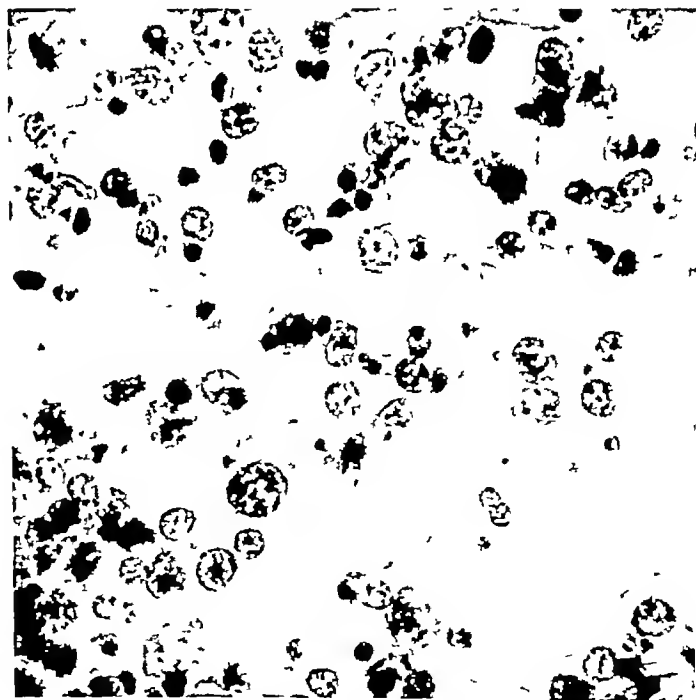


Fig 12 Same case as smear in Fig 11 Smear taken from the tumor showing the same type of cells as were found in the vaginal smear Magnification  $\times 825$

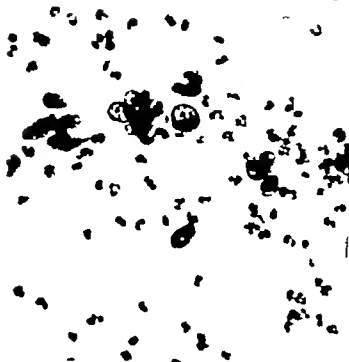


Fig. 3. Epidermoid carcinoma of the cervix. Atypical cells found in the smear. Magnification  $\times 85$ .

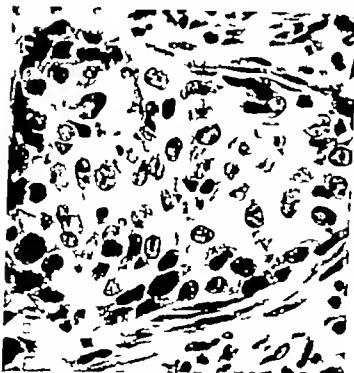


Fig. 14. Histological section of the same tumor (Fig. 3), showing the same type of cells. Magnification  $\times 85$ .

Fig 15 Same case as in Figure 13  
Similar atypical cell seen in smear from  
tumor Magnification  $\times 825$



In some smears the tumor cells are so abnormal that they are easily recognized and the diagnosis is made without difficulty. In other positive cases, the variation from the normal is not so apparent and the diagnosis can be made only after long and careful study has been carried out.

An attempt was made to determine whether the abnormal cells seen in the vaginal smear were actually tumor cells, or whether they represented a tissue reaction secondary to the presence of cancer. Smears were therefore taken from the tumor as soon as it was removed at operation. By taking the smears with a pipette the conditions of the vaginal smear were approximated. Smears were taken from the tumor in 7 cases of cervical cancer and in 3 cases of endometrial cancer. In each case the same type of cell found in the vaginal secretion was found in the smear from the tumor itself (Figs 11 and 12, Figs 13, 14, 15). These observations are presumptive evidence, since the cytology is the same in both cases, that the abnormal cells seen in the vaginal smears are actual tumor cells.

## RESULTS

With the methods described we have studied one or more vaginal smears in 220 cases. No cancer cells were found in smears taken from 153 women. Smears were taken from these patients because they were either in the cancer age or because of symptoms of vaginal bleeding or discharge. Of these, 79 had biopsies, curettage, or hysterectomy with negative tissue diagnosis for cancer. The remainder of these patients with negative smears did not present enough evidence for malignant disease to require operative procedures.

A histological diagnosis of uterine carcinoma was made in 62 cases. Forty-six of these patients were found to have carcinoma of the cervix. Forty of these cancers were epidermoid. There were 3 each of adenocarcinoma and adenoacanthoma. Of the 46 cases with proved cancer of the cervix, positive vaginal smear diagnoses were made in 45—percentage error of 2.2. Ten cases, or 22 per cent, were classified as early (IA) cervical carcinoma.

Twelve cases had endometrial cancer. Ten adenocarcinomas and two adenoacanthomas

were found. Five were classified as early cancer. Of the 12 cases with endometrial cancer 11 were diagnosed with vaginal smear—percentage error of 8.3.

Epidermoid cancer of the vagina was found in 3 patients whose vaginal smears were positive. Cancer cells were found in the vaginal smear taken from 1 patient who had a cancer of the rectum and a rectovaginal fistula. In view of negative pathological findings on examination of the uterine curettements we concluded that the tumor cells probably came from the rectal cancer.

Of 153 negative cases positive smears were reported in 4—error 2.6 per cent.

Vaginal smears diagnosed as positive were taken from 5 patients who have not yet come to operation. They are classified as incomplete

#### EVALUATION OF STUDY

There have been many attempts to diagnose cancer from single cells or groups of cells. The majority of these studies deal primarily with the cells found in pleural and ascitic fluid. In early studies the fluid was smeared on a slide fixed stained and examined. Gradually this method was replaced by centrifuging the fluid, fixing the sediment, imbedding in paraffin cutting and staining. McDonald and Broders believe that smears are as satisfactory as the centrifuged fixed specimen. They publish no statistics. Zemansky using the fixed centrifuged specimen gives statistics on the method in pleural and ascitic fluids. In cases with malignant disease he reports 54 per cent diagnosed accurately. Font using the same method found that carcinoma could be correctly diagnosed in 69 per cent of abdominal fluids and in 31 per cent of thoracic fluids. Font believes that in a diagnosis of cancer the most important criterion is the ratio between the nucleus and nucleolus. Quinzel also emphasizes the importance of the size of the nucleolus. Schlesinger used as criteria of malignancy groups of cells showing polarity, sharply distinct cell walls, and acinar or pseudoacinar formation. He reports 60 per cent accuracy of diagnosis. Graham stresses the importance of true tumor giant cells in serous effusions.

Recently Gower has published results on the examination of the sputum in carcinoma

of the lung. An accurate diagnosis was made in 64.3 per cent of positive cases. As criteria of malignancy he lists abnormalities in size and shape of nucleus, the presence of nuclei often containing more than one nucleolus, and multinucleated giant cells.

As early as 1928 Papanicolaou recognized cancer cells in the vaginal smear. Papanicolaou and Traut (13) in their recent monograph report that they failed to detect malignant cells in 4 of a total of 117 cases with demonstrable cancer of the cervix. They found cancer cells in the vaginal smears of 46 of 53 patients with cancer of the fundus. Our results and those of Papanicolaou indicate that a cancer cell can be more readily identified in the vaginal smear than in body fluid sediments or sputa. This increased accuracy in diagnosis is probably due to the fact that the cells in the vaginal fluid are in greater concentration and have suffered less degeneration.

In considering the mistakes that we have made in diagnosis there are certain important lessons to be learned. Two cases with proved cancer had negative vaginal smears. In each instance only one smear was available for study. It is therefore evident that in any clinically suspicious case one negative smear can not be depended upon to exclude the presence of cancer. We do not know how many negative smears are needed to prove that cancer is not present. Sixteen smears were taken over a period of 7 days from 1 patient with cervical cancer. Cancer cells appeared in 6 smears only.

In 3 cases cancer was indicated by the smear but curettage proved negative. Hysterectomy was not performed. These patients are being carefully followed. In another case the smear was positive. No cancer was found on routine pathological examination after complete removal of the uterus. No serial sections were done and the specimen was discarded by the laboratory.

These mistakes should be considered in relation to the following cases.

ME PC No. 9346. A single woman, aged 69 years, as seen on January 8, 1933. Six months before she had noticed vaginal bleeding, and for months she had colorless vaginal discharge. The tumor as found small and movable. Curettage revealed polypoid mass on the posterior wall of the uterus. The pathologist reported adenocarcinoma.

of the uterus. Before operation a vaginal smear was taken. The uterus, cervix, tubes, and ovaries were removed by total abdominal hysterectomy. The vaginal smear was positive and the report from the pathology laboratory showed fibroids, cervical polyp, multiple follicular cysts of the ovary, stromal hyperplasia of the ovary, but *no cancer*.

This case is one of very early adenoacanthoma (adenosquamous cancer) with positive biopsy and positive vaginal smear, but the laboratory found no evidence of cancer on routine section of the excised uterus. The blocks were discarded and could not be recut.

D Y, P C No 9511. A married woman aged 49 years, with no children, was seen on February 24, 1943, complaining of a discharge since 1931. Three years ago with the menopause the discharge decreased until August, 1942, when it became more profuse and colored. Examination showed a clean cervix with a few exposed cervical ducts. The uterus was forward, of normal size, and movable. There was a mass in the right vault. A vaginal smear was taken and an endometrial biopsy was done. The smear and the biopsy were both positive for endometrial cancer. On March 5, 1943, another smear was taken and was positive. The uterus was removed by means of total abdominal hysterectomy and on examination of the gross specimen the endometrium suggested cancer. About 15 sections of the endometrium were cut and no cancer was found. Blocks were then recut, 50 more sections were made, and in 2 sections adenocarcinoma was found. The diagnosis was confirmed by Dr Tracy B Mallory.

These two cases illustrate that failure to demonstrate cancer on routine pathological examination of the excised specimen does not exclude the presence of cancer. The proof rests upon a negative result following complete serial section of the uterus.

It should be noted that in both these cases in which a positive diagnosis was made by vaginal smear the cancer was in an early stage. To date we have made and confirmed the diagnosis of cancer in 15 early cases.

An example of early cervical cancer diagnosed by the vaginal smear technique follows.

Mrs H W H, P H No 21070, a 43 year old woman, entered the clinic complaining of 1 month's intermenstrual spotting. The cervix presented an erosion of the left anterior lip at the external os. Biopsy revealed chronic cervicitis. No vaginal smear was done. Two months later a small, nonulcerated, hard, nodular area was found in the anterior portion of the left lateral lip. Vaginal smears were positive. After a positive biopsy a Wertheim hysterectomy was done. The cancer measured 1.5 by 1.0 centimeters.

We do not feel justified in advising operation for uterine cancer solely on the evidence of a positive vaginal smear. The positive smears should be confirmed by biopsy or curettage. This method is comparable to tuberculin testing of college students for tuberculosis, who are thereby screened, chest x-ray films being indicated only in the positive reactors.

In our hands this method of diagnosis has proved of significant value. A systematic study of the entire smear and an experienced knowledge of cytology are necessary in this type of examination. We advise incorporation of this method of diagnosis as a part of every routine physical examination in office, outpatient department, and hospital. It is possible that State cancer diagnostic laboratories should make vaginal smear diagnostic service available to the physicians of the community.

#### SUMMARY

We have studied vaginal smears from 220 women in an attempt to make the diagnosis of uterine cancer. The technique, criteria for diagnosis of cancer, and accuracy of diagnosis have been discussed. We believe that by vaginal smear examination uterine cancer can be diagnosed in an early stage.

We express our thanks to Dr George N Papanicolaou for his courtesy and help in this study.

#### REFERENCES

- 1 ADAIR, F L. N. England J M, 1941, 224 497-501.
- 2 BIGELOW, G H, and LOMBARD, H L. Cancer and Other Chronic Diseases in Massachusetts. Boston Houghton, 1933.
- 3 FOOT, N C. Am J Path., 1937, 13 1-12.
- 4 GOWAR, F J S. Brit. J Surg., 1943, 30 193-200.
- 5 GRAHAM, G S. Am J Path., 1933, 9 701-711.
- 6 HAUMEDER, M E. J Lab Clin M., 1938, 23 1046-1051.
- 7 HOGE, R H. Virginia M Monthly, 1942, 69 200-203.
- 8 League of Nations Health Organization. Vols 2 and 3 (quoted by Hoge).
- 9 McDONALD, J R, and BRODERS, H C. Arch Path., 1939, 27 53-60.
- 10 PAPANICOLAOU, G N. Science, 1942, 95 438-439.
- 11 PAPANICOLAOU, G N, and TRAUT, H F. Am J Obst., 1941, 42 193-206.
- 12 Idem. N York State J M., 1943, 43 467-468.
- 13 Idem. Diagnosis of Uterine Cancer by Vaginal Smear. New York: Commonwealth Fund, 1943.
- 14 QUINSEL, ULRIK. Acta med. scand., 1928, 68 427-500.
- 15 SCHLESINGER, M J. Arch. Path., 1939, 28 283-297.
- 16 SIMMONS, C C, and DALAND, E M. Boston M & S J., 1924, 190 15-19.
- 17 TODD, O E. J Michigan M Soc., 1941, 40 191-196.
- 18 ZEMANSKY, A P, Jr. Am J M Sc., 1928, 175 489-504.

# SURGICAL TREATMENT OF ACQUIRED ANEURYSM AND ARTERIOVENOUS FISTULA OF PERIPHERAL VESSELS

## Review of Sixty Seven Cases

JOHN deJ PEMBERTON M.D. F.A.C.S., and B. MARDEN BLACK, M.D.  
Rochester Minnesota

FOR centuries attempts have been made to cure aneurysms of peripheral vessels by surgical methods. Prior to the time of Matas, the classical method of Annyllus and that of Purmann were available for the radical cure of the condition and Hunterian ligation was practiced widely because of the dangers inherent in the direct surgical attack on the aneurysm. Matas performed the first endoaneurysmorrhaphy in March, 1888 and his work during the next few years (11) with that of Halsted led to the modern development of surgery of aneurysms of peripheral vessels.

Arteriovenous fistula was recognized first by William Hunter in 1757 Bresset in 1833 according to Holman (9) attempted in 3 cases to cure the condition surgically by proximal ligation of the artery but gangrene ensued in both cases. Norris, in 1843 reported the first surgical cure which was achieved by proximal and distal ligation of the artery. By 1886 Bramann was able to conclude from a review of 159 cases of arteriovenous fistula, that Hunterian ligation was to be condemned absolutely and that the treatment of choice was quadruple ligation and excision or obliteration of the communication between the artery and the vein. Matas methods of endoaneurysmorrhaphy were applied in the treatment of arteriovenous aneurysm by Beckham in 1904. More recently the many observations and contributions of Watkins Matas (11 12 13) Holman (7 8 9) Reid (20 21 22) and others have clarified the pathological physiology of arteriovenous fistula.

The present review is based on the records of a series of 67 patients who suffered from acquired peripheral aneurysm or arteriovenous fistula or both and who were treated by opera-

tion at the clinic. Several cases of lesions that involved the great vessels leading to the extremities have been included. It was our purpose in reviewing the records of the cases to determine in particular, which operative procedures have been employed and the results following the several different procedures. While acquired arterial aneurysm and arteriovenous fistulas may differ markedly in their causation and symptoms and in the methods necessary for their correction the two types of lesions are similar in that their radical cure often demands that the main arterial supply of the extremity be interrupted. In either case a careful evaluation of the collateral circulation must be made before operation is undertaken.

### SIGNS AND SYMPTOMS

The signs and symptoms of peripheral aneurysm and arteriovenous fistula are well known and usually are so typical that the diagnosis may be made with certainty. In the case of aneurysm the characteristic expansile pulsating tumor situated along the course of a vessel and associated with a systolic bruit and thrill is pathognomonic. Some confusion may arise when the aneurysm is more deep seated or is surrounded by inflammatory thickening of extravasated blood. Interference with the arterial supply to the limb venous stasis with edema, claudication and ischemic neuritis are often present.

Local regional and systemic effects are produced by an arteriovenous fistula. One of us (Pemberton) and Saint proposed that the local effects be considered those shown by the involved vessels the regional effects those manifest in the involved limb and the systemic effects those shown by the general circulatory system. The involved vein shows dilatation tortuosity and elongation while the artery

proximal to the fistula shows dilatation, thinning, and degeneration in all its coats. The involved limb shows hypertrophy, an increased temperature, and trophic effects, which are due to decreased capillary blood flow and to the impeded venous return. The systemic effects, as shown by Holman (8), depend on the size of the fistula and on the unobstructed return flow of blood to the heart. The larger the fistula and the longer it exists, the more likely are cardiovascular changes to develop. These changes are explicable on physiological grounds and depend primarily on an increase of the total volume of the circulating blood per unit of time and particularly on the volume flowing through the circuit of heart, artery, fistula, and vein. The cardiac hypertrophy is a result of the increased work necessary to handle the increased blood flowing through the heart per unit of time, while the dilatation of the heart is part of the general dilatation of the vessels necessary to handle the increased volume of blood flowing through the circuit of the heart, artery, fistula, and vein (7).

In addition to the pulsating, expansile mass and the engorged and often pulsating veins, the continuous bruit and thrill with systolic amplification and the increased beat in the region of the fistula are usually so unmistakable that aneurysm and arteriovenous fistula are not confused. Rarely, studies of the carbon dioxide and oxygen content of blood taken from a vein near the lesion are necessary to distinguish definitely between the two conditions. The transient rise and fall of blood pressure and fall of pulse rate (Branham's bradycardic reaction) when an arteriovenous fistula or the artery proximal to the fistula is occluded, have proved a valuable means of distinguishing between the two conditions.

#### CAUSATION

The causes of aneurysm are numerous but they may be classified rather broadly as inflammation, arteriosclerosis, trauma, embolism, or congenital defect. In the present series of aneurysms, external trauma accounted for 12 cases. One aneurysm of the brachial artery, one of the ulnar artery, and two of the popliteal artery were encountered in 4 patients who did not have any other evidence of inflamma-

tory or degenerative disease of the arteries. Three patients who had popliteal aneurysms and one who had a femoral aneurysm were elderly and had obviously advanced arteriosclerosis. Two patients, each with several aneurysms, had extensive arteritis, in one, the diagnosis was clearly thromboangitis obliterans, and in the other there was extensive migratory phlebitis associated with the arteritis. Three patients had syphilis and in each the aneurysm involved the popliteal artery.

Three patients had an aneurysm of the artery which supplied an arteriovenous fistula and the cause of the aneurysm seemed clearly to be the arterial degeneration caused by the arteriovenous fistula. One of us (Pemberton, 17), in 1930, suggested that the association of an aneurysm with an arteriovenous fistula should not be unusual because of the marked dilatation of the artery proximal to the fistula. As a result of this dilatation, there occur in the wall of the artery degenerative changes, probably produced by partial obstruction of the vasa vasorum. In this way, conditions become ideal for the production of the aneurysm. In one case in which there was a congenital arteriovenous aneurysm of the left foot an aneurysm of the left popliteal artery developed. In another case in which there was a congenital arteriovenous fistula of the right hand and forearm an aneurysm of the right brachial artery developed. In the third there were traumatic arteriovenous fistula involving the left superficial femoral vessels and a huge aneurysm of one of the retroperitoneal vessels in the pelvis.

The great majority of acquired arteriovenous fistulas are due to external trauma in which the vein and the artery are injured simultaneously. In the present series, 32 of the fistulas were caused by gunshot wounds and 6 by stab wounds. In 2 cases the fistulas were the result of a rupture of a spontaneous arterial aneurysm into a vein.

#### TREATMENT

There is some difference of opinion as to when traumatic arterial aneurysms should be operated on. The proponents of immediate operation hold that reparative and restorative operations may be employed more frequently



than is usual and that the dangers of pressure from a progressing hematoma will be lessened. On the other hand the difficulties of operation in the presence of a hematoma and on a patient who has possibly recovered recently from shock are manifest, and, should repair of the injured artery be impossible, there is no alternative except ligation. There is also danger of infection since the operation is conducted in an infected field. Makins stated that operation should be postponed if the hematoma was of a duration of 3 days or more unless hemorrhage was continuing as shown by arterial leakage of blood, increasing tumor or increasing effects of pressure or unless signs of extending infection were present.

In the present series most of the traumatic arterial aneurysms were encountered here long after the stage of hematoma had passed. Operation was performed on two patients 1 month and 2 months respectively after they had sustained gunshot wounds of the popliteal artery and in each case it was necessary to ligate the popliteal artery. Both patients were young men and the results were satisfactory. Another patient who had a stab wound of the brachial artery sustained 2 weeks before he was seen here was treated expectantly with the hope that a more adequate collateral circulation would develop. Operation was made imperative however by a sudden increase of the size of the tumor. The artery was ligated above and below the site of injury and the vein was also ligated. The collateral circulation proved adequate.

There is general agreement (5, 16, 22) that corrective operations on acquired arteriovenous fistulas should be postponed for 3 to 6 months from the time of the injury to allow an adequate collateral circulation to develop. This delay in addition provides time for the absorption of the hematoma, for the subsidence of any infection that may have resulted from the injury and for the possible spontaneous cure of the fistula. In the present series, 3 patients were operated on within 1 month of the time of the injury. In one case early operation was advised because of marked edema and persisting throbbing pain following a gunshot wound of the left popliteal artery. In another case the mass about a brachial ar-

teriovenous fistula enlarged progressively and it was thought that there was danger of a rupture of the sac. The third case was that of a gunshot wound of the shoulder that failed to heal and operation was undertaken under the erroneous clinical impression that the lesion was an infected gunshot wound. In each case the result after operation was satisfactory.

**Collateral circulation.** Before any operation that might involve ligation of the principal artery of an extremity is undertaken, the status of the collateral circulation should be estimated by the use of the Moskowitz-Matas hyperemic test or one of its modifications (12) provided that the proposed site of the arterial obstruction is in a part of the body where the artery is accessible to compression. Should the collateral circulation be found to be inadequate a program of systematic intermittent compression of the artery according to the method of Matas should be instituted. One of us (Pemberton) and McCaughan wrote in 1932 that when such preliminary tests gave evidence of efficient collateral circulation serious ischemia has never been observed in our experience to ensue after permanent occlusion of the artery. As a rule since an arteriovenous fistula probably is the strongest of all stimuli for the production of collateral circulation, there need be little concern about the collateral circulation if the operation has been delayed for 3 to 6 months.

Such is definitely not the case with arterial aneurysms. Most often in cases in which spontaneous peripheral arterial aneurysms develop the patients are old rather than young and the collateral vessels are likely to be the seat of some degree of arteriosclerosis. The aneurysm itself as was pointed out by Theis, absorbs part of the force which normally is expended to drive the blood into the periphery. It is in such cases, in which the aneurysm involves the principal artery of the extremity that the collateral circulation is often found to be doubtful or inadequate. In addition it has been found from collected experience that the ligation of certain arteries, notably the popliteal is followed by a high incidence of gangrene.

Lumbar sympathectomy has been proposed as a method both to increase the collateral

circulation and to prevent immediate post-operative vasospasm Mulvihill and Harvey demonstrated, in dogs, that ligation of one or both external iliac arteries was always followed by a decrease of the temperature of the corresponding foot amounting to 10 to 30 degrees F. In most cases the temperature rose to the original level in about 13 hours. They found that the temperature of the extremity, which had fallen to that of the environment after the ligation of the artery, rose quickly to normal after the removal of the lumbar sympathetic ganglia and that the simultaneous removal of the ganglia with the ligation of the artery prevented the lowering of the temperature of the limb.

One of us (Pemberton) has performed endoaneurysmorrhaphy on 2 patients suffering from popliteal aneurysm on each of whom lumbar sympathectomy had been done previously as a specific measure to increase the collateral circulation. In each case the collateral circulation, as judged by the usual tests, including studies of cutaneous temperature, was doubtful. The results in each case were so striking that the records of the cases are worthy of review.

**CASE 1** A white, American farmer, aged 58 years, was referred to the clinic in January, 1941, for treatment of a popliteal aneurysm, which had been present for 1½ years. About 6 months after the appearance of the tumor, there developed in the region an aching, intermittent pain which always disappeared after 1 or 2 days. There was no increase of the patient's symptoms until 3 weeks before he was seen here when the right leg became moderately swollen. Ten days later there developed in the right calf a severe cramp which lasted for 10 hours and the right foot became pale during this time. The next day another severe cramp set in but there was no change of the color of the foot. The calf remained tender following this attack and the leg became flexed at the knee so that the patient walked with difficulty.

On physical examination it was noted that the patient held the right leg flexed about 30 degrees at the knee. The blood pressure measured 160 millimeters of mercury systolic and 66 diastolic. There was a large pulsating aneurysm of the right popliteal artery, which measured 11 by 10 by 9 centimeters. The pulsations of the dorsalis pedis and posterior tibial arteries were absent on the right. On the left side the pulsations of these vessels were normal. Occlusion of the artery above the aneurysm produced marked pallor of the foot and there was no reactive hyperemia after the clamp was removed. There were

slight venous engorgement and moderate edema of the leg. The results of urinalysis, the blood count and a roentgenogram of the chest were essentially normal. A flocculation test for syphilis gave negative results.

There was considerable doubt as to the adequacy of the collateral circulation, and, consequently, the patient was transferred to the Section of Neurologic Surgery and on January 29, 1941, extensive resection of the right splanchnic nerves with a portion of the right celiac ganglion and lumbar sympathetic trunk, including the 1st, 2d, 3d, and 4th sympathetic ganglia, was performed. Following the sympathectomy, the skin temperature of the right great toe was 33.5 degrees C and that of the left great toe was 25.4 degrees C (temperature of the air 25.5 degrees C). In a cool room (air temperature 21.4 degrees C) the temperature of the skin of the right great toe was 32.7 degrees C, that of the left 22.1 degrees C.

Fifteen days after sympathectomy, endoaneurysmorrhaphy was performed. There was a perforating fusiform aneurysm of the right popliteal artery, which measured 8 to 10 centimeters in diameter. The popliteal artery was ligated proximally and distally with silk, the sac was opened and the blood clot was evacuated. The sac was then obliterated, surgical gut sutures being used. Following operation, the foot on the side on which operation had been performed was warmer than that on the other side. The patient made an uneventful recovery, and 3 months after the endoaneurysmorrhaphy, the right foot was still warmer than the left and the patient had been relieved of all symptoms.

**CASE 2** The second patient was a Puerto Rican sugar plantation owner, aged 68 years, who had always been in good health until 10 months before coming to the clinic. At that time he had a cramping pain in the calf of the left leg for about 15 minutes. This pain had recurred periodically since, not always with exercise, but absolute rest always gave relief. The pain had persisted at times for several days. About 6 weeks before the patient was seen here, his left great toe became swollen, tender and cyanotic, and since then the entire left foot had been colder than the right and somewhat blue. The diagnosis of popliteal aneurysm was made elsewhere at the time when gangrene of the foot seemed imminent.

The pertinent findings on physical examination were as follows. The blood pressure measured 120 millimeters of mercury systolic and 70 diastolic. There was an aneurysm approximately 6 by 5 by 4 centimeters involving the left popliteal artery. The pulsations of the left dorsalis pedis and posterior tibial arteries were absent while pulsations were present in these vessels on the right. There was marked pallor on elevation of the leg with less marked rubor on dependency and clinical tests were interpreted as indicating a doubtful collateral circulation. All collateral pulsations disappeared when the aneurysm was compressed and there was marked pallor on elevation with persistent pallor on dependency. In addition to the findings in the leg,

evidence of bronchiectasis, an inguinal hernia and a moderately hypertrophied prostate were found. The temperature of the skin of the right great toe was 28.2 degrees C. and that of the left 27.3 degrees C. (air temperature 3.2° C.). With the aneurysm occluded by means of a clamp the temperature of the skin of the right great toe was 3.5 degrees C. and that of the left great toe was 3.0 degrees C. (air temperature 31.0° C. the patient had been in a warm room longer than when previous observations were made). The results of urinalysis, the blood count, and a roentgenogram of the chest were essentially normal. A flocculation test for syphilis gave negative results.

Left lumbar sympathectomy and trunk resection, including the 1st, 2d and 3d lumbar ganglia and intervening sympathetic trunk, were performed on August 1, 1934 by members of the Section on Neurologic Surgery. The day after sympathectomy the skin temperature of the right great toe was 27.1 degrees C. and that of the left as 32.3 degrees C. (observations made in patient's room at temperature not recorded). Intermittent clamping of the artery proximal to the aneurysm was continued until it was possible to leave the clamp on for 30 to 40 minutes without the patient's suffering any particular pain.

Twenty days after sympathectomy endoaneurysmorrhaphy was performed. It was found that practically the entire popliteal artery was involved by the aneurysm, which was 5 or 6 centimeters in diameter. The popliteal artery was ligated just proximal and distal to the aneurysm, the sac was opened and the clot was removed. The sac was then obliterated, surgical gut sutures being used. The day after operation the foot was of good color and the temperature of the skin of the two feet was practically the same. Five days later the temperature of the skin of the left great toe was 8.6 degrees C. and that of the right 7.0 degrees C. (air temperature 3.1° C.). The patient made an uneventful recovery and the left foot and leg remained warmer than the right.

#### ARTERIAL ANEURYSM

The following methods were used in the treatment of patients who had arterial aneurysms on the present series: (1) obliterative endoaneurysmorrhaphy with or without proximal and distal ligation fourteen times; (2) proximal and distal ligation of the artery and excision of the aneurysm twelve times; (3) restorative endoaneurysmorrhaphy two times; (4) proximal ligation, two times; (5) a clamp was placed on the artery proximal to an aneurysm in 1 case and the rupture elsewhere of an aneurysm that developed proximal to a congenital arteriovenous fistula led to amputation of the leg which was done elsewhere.

*Obliterative endoaneurysmorrhaphy* This procedure occasionally with the slight modification of extrasaccular proximal and distal ligation of the artery or of proximal ligation of the artery was employed more frequently than any other in the present series. As a rule temporary compression of the main afferent and efferent arteries was effected while the sac was opened and the blood clot was evacuated. The status of the collateral circulation was evaluated further by releasing the temporary ligature on the efferent artery and noting the amount of retrograde bleeding (Henle-Coenen test 18). The endoaneurysmorrhaphy was carried out and permanent ties were substituted often for the tapes used to occlude the main arteries temporarily. The results after this operation were uniformly satisfactory and in no case was gangrene observed. One patient who had popliteal aneurysm had edema of the leg after operation. One patient who had an aneurysm of the brachial artery which had developed secondarily to a congenital arteriovenous fistula of the forearm had so much pain in the region of the congenital fistula that amputation of the arm became necessary. There was no evidence of arterial insufficiency either clinically or from dissection of the surgical specimen.

*Proximal and distal ligation of the artery and excision of the aneurysm* This procedure has the obvious advantage that there is no mass of tissue left behind at the site of the aneurysm, but it is more difficult technically than obliterative endoaneurysmorrhaphy and there is greater interference with the surrounding structures and with the collateral circulation. It usually is the procedure of choice to treat aneurysms that involve secondary arteries of an extremity. In the present series, it was not limited to the treatment of such aneurysms but was performed in 4 cases of popliteal and 2 of superficial femoral aneurysm. The results were entirely satisfactory in 11 of the 12 cases. In the remaining case an aneurysm of the superficial femoral artery gangrene ensued in spite of the fact that the vein was ligated. This patient was 68 years of age and had marked peripheral arteriosclerosis.

*Restorative endoaneurysmorrhaphy* This procedure was attempted in 2 cases only both

TABLE I.—PERIPHERAL ARTERIAL ANEURYSMS IN SERIES VESSEL INVOLVED, TYPE OF OPERATION AND RESULT OF TREATMENT

Artery involved*	Operative method	Results and comment
Popliteal	Obliterative endoaneurysmorrhaphy 7 cases	All satisfactory. Edema of leg 1 case. Two patients had previous lumbar sympathectomy
	Ligation and excision 4 cases	All satisfactory
	Restorative endoaneurysmorrhaphy 1 case	Satisfactory
	Amputation (elsewhere) 1 case	Aneurysm developed in artery leading to congenital arteriovenous fistula. Rupture of aneurysm led to amputation elsewhere
Femoral	Neff clamp 1 case	No follow up
	Obliterative endoaneurysmorrhaphy 1 case	Satisfactory
	Proximal ligation Ligation and excision Excision entire femoral artery (elsewhere) } same case	Patient had had previous amputation. Large aneurysm in stump. After proximal ligation aneurysm did not pulsate but sac acted as foreign body. Necessary ultimately to remove entire femoral artery which was done elsewhere
Superficial femoral	Ligation and excision—vein ligated 2 cases	Gangrene and amputation 10 1 case
	Obliterative endoaneurysmorrhaphy 3 cases	All satisfactory
	Restorative endoaneurysmorrhaphy 1 case	Result poor. Patient stated he was not helped. Tumor present
Brachial	Obliterative endoaneurysmorrhaphy 2 cases	In 1 case aneurysm in artery leading to congenital arteriovenous fistula. Amputation necessary because of pain
	Ligation and excision 2 cases	Satisfactory results
Radial	Ligation and excision 1 case	Satisfactory result
	Ligation 1 case	Hematoma stage. Result satisfactory
Ulnar	Ligation and excision 1 case	Satisfactory result
	Obliterative endoaneurysmorrhaphy 1 case	Satisfactory result
Superficial volar arch	Ligation and excision 1 case	Satisfactory result

\*In some cases a patient had aneurysms of more than one artery

operations having been done in the earlier years covered by the study. The result of the operation on a popliteal aneurysm was satisfactory. In the other case, in which there was a sacculated aneurysm of the superficial femoral artery, the operation seemed satisfactory technically, and the closure of the communication between sac and artery was reinforced by flaps taken from the sac. However, 10 months after operation, the patient still had a tumor and stated that his leg had not been helped in any way.

The other procedures listed have been used only in isolated instances and to cope with unusual situations.

In Table I the cases of arterial aneurysm are distributed according to artery involved, type of operation, and result of treatment.

#### ARTERIOVENOUS FISTULA

The following types of operation were used to treat the 40 patients who had arteriovenous fistula reviewed in the present series: (1) prox-

imal and distal ligation of the principal artery and vein and excision of a segment of artery and vein with the communication (quadruple ligation and excision), sixteen times, (2) ligation of the communication between artery and vein, five times, (3) proximal ligation of the artery and vein, five times, (4) proximal ligation of the artery and vein and ligation or obliteration of the communication, five times, (5) other procedures.

*Quadruple ligation and excision.* Most authors agree that this is the procedure of choice for the radical cure of arteriovenous fistula, and our experience is in keeping with this view. Sixteen patients in the present series were treated in this manner with results that were entirely satisfactory for 14. It is evident that this procedure offers the best chance to cure the lesion and it was employed twice in the present series after the failure of other less radical operations. The only complication attributable directly to the operation was the death of one patient from a massive pulmo-

TABLE II—ARTERIOVENOUS FISTULAS IN SERIES ARTERY INVOLVED TYPE OF OPERATION AND RESULT OF TREATMENT

Artery involved	Operative method	Results and comment
Femoral (In several cases arterial (but actually ligated)	Quadruple ligation and excision, case	Results satisfactory
	Quadruple ligation and excision (common, profunda and superficial femoral ligated), case	Results satisfactory
	Proximal and distal ligation of artery (common, profunda and superficial femoral ligated). Vein not ligated, case	Gangrene and amputation 1 month later stump ruptured due to work later. Distal ligated. Death elsewhere
	Proximal ligation artery and vein, case	Massive arterial thrombus 9th day after operation. Gangrene and amputation
	Communication ligated, case	Case satisfactory case good result
	Proximal and distal ligation artery Communication closed from main artery case	Result satisfactory
Superficial femoral	Quadruple ligation and excision, case	case secondary aneurysm in pch. case sudden death (pulmonary embolism) 5 hours after operation. Results satisfactory otherwise
	Quadruple ligation and obliteration or ligation of femora, case	case recurrence of arteriovenous fistula. Case followed quadruple ligation and excision. Result in other case good
	Quadruple ligation, case	Still in hematoma stage—Case pending
	Communication ligated, case	Fistula persisted. No disability in progression of symptoms and nothing further advised
	Quadruple ligation and endovascular anastomosis case	Result satisfactory
Popliteal	Communication ligated, case	case result satisfactory case necessary to occlude communication and to ligate vessels because of hemorrhage, gangrene and amputation followed
	Proximal and distal ligation artery and vein Partial excision of sac, case	Result satisfactory
	Proximal ligation artery and vein, ligation of common ilium, case	Result satisfactory
	Endovascular anastomosis—vein ligated, case	Recurrence. No further treatment. Had thick, slow
	Proximal and distal ligation of artery Vein repaired, case	Eight years, otherwise satisfactory
Profunda femoral	Quadruple ligation, communication ligated, case	Result satisfactory
	Proximal ligation artery and vein, case	Thick still present after operation. Ulcerous cure from quadruple ligation and excision
Posterior tibial	Quadruple ligation and excision, case	Result satisfactory
Peroneal	Proximal and distal ligation and excision of veins, case	Result satisfactory
Subclavian	Fistula and vein ligated, case	Good result
	Quadruple ligation and excision, case	Good result
Axillary	Artery ligated above and below	Beck's phase injury operation months later Arteriovenous communication still open
	Vein ligated above, case	
	Rem of fistula reduced, case	Chief in injury to bechal phase. Fistula still present
	Proximal and distal ligation, case	In hematoma stage Result satisfactory
Beck's	Quadruple ligation and excision, case	Results satisfactory
Distal	Amputation of finger, case	Case

nary embolism 5 hours after the conclusion of the operation. The patient had severe congestive heart failure due to an arteriovenous fistula involving the superficial femoral vessels.

Another patient who had an arteriovenous fistula of the superficial femoral vessels had, in addition a huge aneurysm of one of the pelvic vessels. This was opened and packed. The

circulation in the leg was adequate for 8 years but ultimately evidence of arterial insufficiency and venous stasis developed and the leg was amputated 14 years after the operation on the fistula.

*Ligation or occlusion of the communication between the artery and vein.* Practically conditions for the employment of this procedure are encountered rarely and there is always some

chance that the fistula may re-establish itself or that bleeding may develop because of degenerative changes in the walls of the fistula or in the vessels. It was attempted in 5 cases only and in 3 the results were unsatisfactory. In 1 case, serious bleeding necessitated reoperation, at which time the vein was ligated and a repair of the artery was attempted. This procedure was followed by gangrene, and amputation later became necessary. In another case, the thrill and bruit recurred on the 7th day after ligation of the fistula. This patient was cured ultimately by quadruple ligation and excision. The symptoms of the third patient who had recurrence did not progress and further treatment was not necessary.

*Proximal ligation of artery and vein.* This procedure was carried out in 5 cases with satisfactory results in 3. One patient had a recurrence within 1 year and in the other case there developed, on the 5th day after the femoral artery and vein had been ligated, a massive arterial thrombus which ultimately resulted in gangrene and amputation.

*Proximal and distal ligation of artery and vein with ligation or occlusion of the communication.* The results after this procedure were satisfactory in 4 of the 5 cases in which it was attempted. In 1 case a recurrence developed 18 months after the original operation. The patient was cured ultimately by quadruple ligation and excision.

In several cases in which the condition was treated before 1917, when Makins' work became known, the artery was occluded and the patency of the vein was maintained. In the light of present knowledge, such methods are largely obsolescent. Of the 5 patients treated by proximal and distal ligation of the artery and occlusion of the fistula, with repair of the vein, there were 2 cures, 1 case of gangrene, 1 case of chronic edema and ulceration, and 1 recurrence.

The vein and the communication between artery and vein were obliterated and the patency of the artery was maintained in 4 cases. Recurrence of the fistula occurred in 2 cases.

Other procedures largely governed by the anatomic situation of the fistula, were used

occasionally. An arteriovenous fistula situated in the finger was cured by amputation of the finger. In 2 cases of fistula involving the axillary vessels in both of which there was extensive injury of the brachial plexus, the condition was treated, in the 1 case by narrowing the fistula and in the other by proximal and distal ligation of the artery. The procedures in both cases were limited because of the danger of further injury of a nerve. Another patient, who had an axillary arteriovenous fistula still in the hematoma stage, was operated on under the erroneous impression that the lesion was an infected wound. A cure resulted from proximal and distal ligation of the artery.

In Table II the cases of arteriovenous fistula are distributed according to the artery involved, the type of operation performed, and the result of treatment.

#### SUMMARY

From a review of the records of 67 patients who suffered from acquired, peripheral aneurysm and arteriovenous fistula and who were treated by operation at the clinic, it would seem that the exact diagnosis can be made usually before operation and that a correct evaluation of the status of the collateral circulation is possible by means of clinical tests before operation and by noting the amount of retrograde bleeding from the principal artery at the time of operation (Henle-Coenen test). In cases of arterial aneurysm of the leg in which there is doubtful collateral circulation, much improvement can be expected to follow lumbar sympathectomy, and postoperative vasospasm is also prevented. Endoaneurysmorrhaphy with or without extrasaccular ligation of the principal artery, and proximal and distal ligation of the artery and excision of the sac are the procedures of choice for the treatment of aneurysms of peripheral arteries. In the case of peripheral arteriovenous fistula, the procedure of choice for the radical cure of the condition is clearly quadruple ligation and excision. Another satisfactory but less certain procedure is quadruple ligation and obliteration and occasionally simple ligation of the communication between artery and vein may be carried out.

## REFERENCES

1. BUCKER, W. S. *Ann. Surg.* 904, 30 767-775.
2. BAKER, F. *Arch. Gen. Chir.*, 880, 15 -107.
3. BARNES, H. H. *Internat. J. S.* 890, 3 50-5.
4. BRECHET, GILBERT. Quoted by Halbram, Emilie (9).
5. COMPTON, I. *Internat. Clin.*, 920, 3 27-30.
6. H. LITTELL, W. S. *J. Exp. M.*, 9 6, 24 27 286.
7. HOLMAN, EMILIE. *Arch. Surg.* 924, 7 64-8.
8. *Ibid.* 924, 9 855-872.
9. *Idem*. *Arteriovenous Aneurysms, Abnormal Communications between the Arterial and Venous Circulations*. P. 45. New York: The Macmillan Co., 937.
10. MARRAS, C. H. *On Gunshot Injuries to the Blood-Vessels*. P. 8. Bristol: John Wright and Sons, Ltd. 99.
11. AL, RUDOLPH. *Ann. Surg.* 902, 37 6 96.
12. *Idem*. *J. Am. M. Ass.* 914, 63 441-447.
13. *Idem*. *Ann. Surg.*, 920, 7 4 3-437.
14. MURPHY, D. A. and HARRIS, S. C. *J. Clin. Invest.*, 91 4 3-432.
15. NORMAN, O. B. *Am. J. M. Sc.*, 843, 3 27-3.
16. PENNINGTON, J. DE J. *Arch. Surg.* 924, 6 497-491.
17. *Idem*. *Proc. M. Y. Clin.*, 910, 3 2.
18. PENNINGTON, J. J. and MCCARTHY, J. M. *Ann. Surg.* 932, 96 5-6.
19. PENNINGTON, J. DE J. and SURVEY, J. H. *Surg. Gyn. Obst.* 118, 46 470-483.
20. REYNOLDS, M. R. *Bull. Johns Hopkins Hosp.* 920, 3 43-50.
21. *Idem*. *Ann. Surg.* 932, 95 378-389.
22. REYNOLDS, M. R., and MCCARTHY, JOSEPH. *Ann. Surg.* 934, 98 643-663.
23. THORNTON, T. V. *Surgery* 937 327-347.

# A NEW TEST FOR PANCREATIC FUNCTION

## II Experimental Observations

H L POPPER, M D, WILLIAM H OLSON, and H NECHELES, M D, Ph D, Chicago, Illinois

THE results of animal experiments concerning a new pancreatic function test, applicable to use in the human, were published recently (3)

The diagnostic possibilities of changes in blood amylase or lipase following vigorous stimulation of the external pancreatic secretion with either mecholyl (acetyl- $\beta$ -methylcholine chloride)<sup>1</sup> plus eserine or with secretin were demonstrated. The minimal doses of mecholyl and eserine, which would cause an increase of the two blood enzymes in cases with a normal pancreas, were established, and it was shown that these doses could be further reduced by giving the drugs twice at a 15 minute interval. Several weeks after obstruction of one or both pancreatic ducts, when atrophy of the glandular tissue had occurred, no increase of blood enzymes occurred following the administration of the drugs mentioned. It seemed probable that in clinical cases the injection of mecholyl and eserine would enable us to uncover pathological processes of the pancreas, characterized by decreased production of pancreatic juice, such as atrophy of the pancreas, chronic pancreatitis, cirrhosis of the pancreas, or secretory insufficiency. The doses of mecholyl and eserine used in these experiments, though causing no untoward reactions in dogs, were still too great to be applied safely to the human. Smaller doses, however, may prove effective for clinical use.

In a second series of experiments secretin was used. The maximum dose of this drug was determined, which did not cause an increase of blood enzymes in the presence of a normal pancreas. In animals with obstructed pancreatic ducts, injection of this dose of secretin was followed almost regularly for sev-

eral weeks after operation by an increase of the two blood enzymes, especially of the blood lipase. Applied to the human this procedure can be expected to reveal disturbances to the normal flow of the pancreatic juice, as may occur in tumors of the pancreas or of the papilla, pancreatic cysts, pancreatic stones and, possibly, subacute pancreatitis.

Comfort and Osterberg in studies on the human have shown that the combination of mecholyl and secretin stimulated pancreatic secretion more vigorously than any other drug or combination of drugs tried. Although their procedure of duodenal aspiration and of enzyme determinations in the duodenal contents was different from our procedure of employing changes in serum enzymes for the determination of pancreatic function, it was apparent that their method of stimulation of the pancreas by mecholyl plus secretin might be useful for our test.

### METHODS

The effects on blood lipase of varying doses of mecholyl plus secretin were assayed on normal dogs first and, after an adequate dosage had been established, on dogs with obstructed pancreatic ducts. Obstruction was produced by ligation and division of one or both pancreatic ducts, with or without partial separation of the pancreas from the duodenum. All animals were reoperated upon at appropriate intervals in order to ascertain the condition of the pancreas, biopsies of the pancreas were taken for histological study.

The animals were starved for 20 hours before the experiments. A control sample of venous blood was drawn first, and then mecholyl was injected subcutaneously. Five minutes later, secretin in a 100 milligrams per cent solution was slowly injected intravenously. Blood samples were drawn 30, 60 and 90, or 120 minutes after the injection of mecholyl. Serum lipase determinations by the method of Crandall and Cherry were performed im-

<sup>1</sup>From the Department of Gastro Intestinal Research of Michael Reese Hospital.

This work was supported by the Michael Reese Research Foundation and by a grant from the Rosetta Josephson Fund.

<sup>1</sup>Mecholyl supplied by Merck and Co.



TABLE I.—THE EFFECTS OF MECHOLYL AND OF SECRETIN ON THE SERUM LIPASE OF NORMAL DOGS

No. of dog				1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22		23		24		25		26		27		28		29		30		31		32		33		34		35		36		37		38		39		40		41		42		43		44		45		46		47		48		49		50		51		52		53		54		55		56		57		58		59		60		61		62		63		64		65		66		67		68		69		70		71		72		73		74		75		76		77		78		79		80		81		82		83		84		85		86		87		88		89		90		91		92		93		94		95		96		97		98		99		100		101		102		103		104		105		106		107		108		109		110		111		112		113		114		115		116		117		118		119		120		121		122		123		124		125		126		127		128		129		130		131		132		133		134		135		136		137		138		139		140		141		142		143		144		145		146		147		148		149		150		151		152		153		154		155		156		157		158		159		160		161		162		163		164		165		166		167		168		169		170		171		172		173		174		175		176		177		178		179		180		181		182		183		184		185		186		187		188		189		190		191		192		193		194		195		196		197		198		199		200		201		202		203		204		205		206		207		208		209		210		211		212		213		214		215		216		217		218		219		220		221		222		223		224		225		226		227		228		229		230		231		232		233		234		235		236		237		238		239		240		241		242		243		244		245		246		247		248		249		250		251		252		253		254		255		256		257		258		259		260		261		262		263		264		265		266		267		268		269		270		271		272		273		274		275		276		277		278		279		280		281		282		283		284		285		286		287		288		289		290		291		292		293		294		295		296		297		298		299		300		301		302		303		304		305		306		307		308		309		310		311		312		313		314		315		316		317		318		319		320		321		322		323		324		325		326		327		328		329		330		331		332		333		334		335		336		337		338		339		340		341		342		343		344		345		346		347		348		349		350		351		352		353		354		355		356		357		358		359		360		361		362		363		364		365		366		367		368		369		370		371		372		373		374		375		376		377		378		379		380		381		382		383		384		385		386		387		388		389		390		391		392		393		394		395		396		397		398		399		400		401		402		403		404		405		406		407		408		409		410		411		412		413		414		415		416		417		418		419		420		421		422		423		424		425		426		427		428		429		430		431		432		433		434		435		436		437		438		439		440		441		442		443		444		445		446		447		448		449		450		451		452		453		454		455		456		457		458		459		460		461		462		463		464		465		466		467		468		469		470		471		472		473		474		475		476		477		478		479		480		481		482		483		484		485		486		487		488		489		490		491		492		493		494		495		496		497		498		499		500		501		502		503		504		505		506		507		508		509		510		511		512		513		514		515		516		517		518		519		520		521		522		523		524		525		526		527		528		529		530		531		532		533		534		535		536		537		538		539		540		541		542		543		544		545		546		547		548		549		550		551		552		553		554		555		556		557		558		559		560		561		562		563		564		565		566		567		568		569		570		571		572		573		574		575		576		577		578		579		580		581		582		583		584		585		586		587		588		589		590		591		592		593		594		595		596		597		598		599		600		601		602		603		604		605		606		607		608		609		610		611		612		613		614		615		616		617		618		619		620		621		622		623		624		625		626		627		628		629		630		631		632		633		634		635		636		637		638		639		640		641		642		643		644		645		646		647		648		649		650		651		652		653		654		655		656		657		658		659		660		661		662		663		664		665		666		667		668		669		670		671		672		673		674		675		676		677		678		679		680		681		682		683		684		685		686		687		688		689		690		691		692		693		694		695		696		697		698		699		700		701		702		703		704		705		706		707		708		709		710		711		712		713		714		715		716		717		718		719		720		721		722		723		724		725		726		727		728		729		730		731		732		733		734		735		736		737		738		739		740		741		742		743		744		745		746		747		748		749		750		751		752		753		754		755		756		757		758		759		760		761		762		763		764		765		766		767		768		769		770		771		772		773		774		775		776		777		778		779		780		781		782		783		784		785		786		787		788		789		790		791		792		793		794		795		796		797		798		799		800		801		802		803		804		805		806		807		808		809		810		811		812		813		814		815		816		817		818		819		820		821		822		823		824		825		826		827		828		829		830		831		832		833		834		835		836		837		838		839		840		841		842		843		844		845		846		847		848		849		850		851		852		853		854		855		856		857		858		859		860		861		862		863		864		865		866		867		868		869		870		871		872		873		874		875		876		877		878		879		880		881		882		883		884		885		886		887		888		889		890		891		892		893		894		895		896		897		898		899		900		901		902		903		904		905		906		907		908		909		910		911		912		913		914		915		916		917		918		919		920		921		922		923		924		925		926		927		928		929		930		931		932		933		934		935		936		937		938		939		940		941		942		943		944		945		946		947		948		949		950		951		952		953		954		955		956		957		958		959		960		961		962		963		964		965		966		967		968		969		970		971		972		973		974		975		976		977		978		979		980		981		982		983		984		985		986		987		988		989		990		991		992		993		994		995		996		997		998		999		1000		1001		1002		1003		1004		1005		1006		1007		1008		1009		1010		1011		1012		1013		1014		1015		1016		1017		1018		1019		1020		1021		1022		1023		1024	
------------	--	--	--	---	--	---	--	---	--	---	--	---	--	---	--	---	--	---	--	---	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--	------	--

TABLE III—PERSISTENT POSITIVE LIPASE TESTS FOLLOWING OBSTRUCTION OF THE PANCREATIC DUCTS OF DOGS

Dog No	Minutes after injection	Days after obstruction										
		0	16	30	38	44	59	67	76	84	105	106
4	0	1 2		1 5			1 6		1 2		1 0	
	30	2 1		3 3			4 6		4 3		3 1	
	60	1 6		2 7			4 2		3 8		2 6	
	90	1 9					3 6		3 5		2 7	
14	0	0 5	0 4			1 0				0 4		
	30	1 3	2 8			3 2				1 0		
	60	1 2	2 2			2 1				0 7		
	90	1 0				2 5				0 7		
18	0				0 0			1 2				0 3
	30				2 8							4 5
	60				3 0			2 4				3 1
	90							2 0				1 1

a marked increase of serum lipase, with a peak 30 to 60 minutes after the injection. No untoward reactions were observed. We, therefore, decided to use a standard dosage of 0.22 milligram of mecholyl and of 2 milligrams of secretin per kilogram because in our experiments its effectiveness was always distinct and reliable, and because the dosage of mecholyl was below the maximal subcutaneous dose which can be used in the human.

After having established a dosage of mecholyl and of secretin which caused a consistent increase of serum lipase in normal dogs, we proceeded to experiment on 10 dogs with obstructed pancreas. In 7 of these animals, a mecholyl-secretin test had been performed prior to the obstruction (0.015 mgm mecholyl per kgm in one animal and 0.022 mgm in the other animals).

Dogs 1, 5, 9, 10, 11, and 13 had a positive serum lipase response to the injections up to 16 to 59 days after operation. When the tests were repeated 30 to 84 days, respectively, after operation, they were negative. Likewise in dog 17, 240 days after operation, the test was negative (Table II).

Three dogs had a persistently positive lipase reaction 84, 105, and 106 days, respectively, after the operation (Table III). At reoperation it was found that in none of them atrophy of the pancreas had occurred, but that only a moderate degree of induration was present. On the other hand, 6 of the 7 dogs with a negative test 30 to 84 days after obstruction (Table II) showed an advanced degree of cirrhosis and atrophy of the pancreas, such as is usually seen some time after complete ob-

struction. However, the 7th dog (No. 5) with negative lipase reactions 76 and 105 days after obstruction, had an almost normal pancreas. We were not able to find an explanation for this latter finding.

#### ANALYSIS OF STUDY

Our results show that in normal dogs injection of mecholyl plus secretin in the aforementioned doses regularly caused a marked increase of serum lipase, which reached its peak usually 30 to 60 minutes after injection. Following obstruction of the pancreas, in some dogs, the lipase response was greater than before for several weeks (Nos. 4, 5, 13, 14) while in other dogs it remained almost the same (Nos. 9 to 11). This demonstrated, that the mecholyl plus secretin test was not useful in acute obstruction of the pancreas. If the obstruction was not followed by cirrhosis and atrophy of the pancreas, the test, with one exception, remained permanently positive. If, however, a permanent damage to the glandular tissue of the pancreas ensued, the mecholyl-secretin test became consistently negative.

These results justify the conclusion that determination of serum lipase after administration of mecholyl plus secretin gives significant information concerning the functional ability of the pancreatic gland and that it may be used successfully in humans for the diagnosis of disorders of the pancreas, as, for example, functional insufficiency, chronic pancreatitis, or pancreatic cirrhosis.

These mecholyl-secretin tests yielded results similar to those previously reported with

the combined administration of mecholyl and cerine (3) but they were more consistent and they were obtained with doses of mecholyl which may be used in the human, while the previously reported doses of mecholyl and of cerine were too large for clinical application (3).

The previously reported administration of secretin alone did not cause an increase of serum enzymes in dogs with a normal pancreas while after obstruction of the pancreas secretin tests revealed a marked response of serum enzymes, which could be repeated for several weeks.

We have thus employed two types of stimulation of the pancreas for our diagnostic tests. For the first type of stimulation a dose of secretin was chosen which did not produce an increase of serum enzymes in the presence of a normal pancreas, but raised them in the case of pancreatic obstruction. The second type of stimulation was produced with a stronger stimulant, mecholyl plus secretin which raised blood enzymes in the case of a normal pancreas as well as in the case of pancreatic obstruction but not in case of severely damaged glandular pancreatic tissue. In clinical use the latter more severe test would have to be employed only after the first and milder one would be negative. Both tests are not necessary in the very acute stages of pancreatitis in which stimulation of pancreatic secretion might be harmful and in which sam-

ple determination of serum amylase or lipase without stimulation will give sufficient information, by showing increased enzyme levels.

Two of the main features of pathology of the pancreas, obstruction to the outflow of pancreatic juice and insufficient production of pancreatic juice can be revealed by studying the serum lipase following administration of secretin alone and of mecholyl plus secretin.

#### SUMMARY

Stimulation of pancreatic secretion with mecholyl plus secretin caused an increase of serum lipase in normal dogs while in the case of cirrhosis and atrophy of the pancreas no increase of serum lipase occurred.

The administration of mecholyl plus secretin may be used as a test for the secretory ability of the pancreas.

In clinical use the administration of secretin alone and of mecholyl plus secretin may supplement each other successfully in the diagnosis of obstruction and of secretory insufficiency of the pancreas.

Clinical tests with secretin and secretin plus mecholyl are in progress.

#### REFERENCES

- CONQUEST, A. W. and OBERHART, L. E. *Arch. Int. M.* 92, 66 688
- CRANDALL, L. A. J. and CARR, I. S. *Am. J. Physiol.* 93 90 166
- POWELL, H. L. and VICKERLEY, H. *Gastroenterology* 94, 490

# STUDIES ON THE THERAPY OF HEMORRHAGIC SHOCK

## II The Effects of Iso-Osmotic and of Concentrated Serum and Plasma in Dehydrated Dogs

S O LEVINSON, M D, MARTHA JANOTA, M S, R E WESTON, M D, Ph D, and  
H NECHELES, M D, Ph D, Chicago, Illinois

**I**N a previous paper (11) the therapeutic effects of iso-osmotic and concentrated plasma protein solutions on hemorrhagic shock in normal dogs were compared. In this paper a comparable study on dehydrated dogs is presented.

The procedures were the same as previously described. Shock was produced by graded bleeding in unanesthetized dogs and iso-osmotic or concentrated canine serum or plasma was administered to animals at different levels of circulatory collapse. In the warmer weather the animals were deprived of both food and water for 18 to 30 hours before each experiment. In the colder weather this period of fluid deprivation was inadequate. It was necessary to place the animals on a dry diet and to restrict water intake for 48 to 72 hours. The individual variability of the animals and the complexity of the factors influencing the state of hydration made it difficult to estimate the degree of dehydration of the individual animal before the experiment. Unfortunately, the normal values for thiocyanate dilution vary markedly with size, age, sex, and other factors and, therefore, give no valid index of the degree of dehydration of the individual animal (5).

Because the degree of shock has an important bearing on the response to infusion, two comparable groups of animals in various degrees of shock were infused with iso-osmotic or with concentrated serum or plasma, and the clinical response, cardiovascular, and blood changes, and survival times were studied after infusion.

From the Samuel Deutsch Serum Center and from the Department of Gastro Intestinal Research of Michael Reese Hospital, Chicago. V Weissman was most helpful in the carrying out of this study.

This work was done under the auspices of the Committee on Research in Shock of the Michael Reese Hospital and was supported by the Michael Reese Research Foundation.

### EXPERIMENTAL OBSERVATIONS

In an earlier publication the influence of dehydration on the development of posthemorrhagic shock has been discussed (15), with particular emphasis on the hemoconcentration which frequently follows hemorrhage in dehydrated animals. Due to the decreased fluid reserve resulting from water deprivation, dehydrated animals cannot compensate for blood loss as well as normal animals. Thus, dehydrated animals after less bleeding develop severer degrees of circulatory collapse or shock than do normally hydrated dogs. Many such animals either expire during or shortly after the completion of the 26 minute period required for the posthemorrhage plasma volume determination, or else deteriorate so badly that recovery after any type of infusion could not be expected.

This inability of the dehydrated animals to compensate for loss of blood was particularly notable in the summer months when, not infrequently, animals deprived of water for only 18 hours would develop severe shock after a single hemorrhage totalling only 25 to 30 per cent of the initial blood volume. In such an animal, the blood pressure, instead of gradually rising above the low level at the end of the bleeding period, would continue to fall and the animal's general condition one-half hour or so after the hemorrhage obviously would be critical. At this time, many of these animals would have an increased hematocrit and, subsequently, either would fail to live through the blood volume determination or would be beyond the point where they could be restored completely by infusion.

In the colder weather, animals deprived of water for only 18 hours reacted to hemorrhage in the same manner as did normal dogs, sometimes tolerating as many as four or five re-

peated hemorrhages with progressive hemodilution maintaining the plasma volume blood pressure and carbon dioxide at diminished, but above shock, levels. Moreover in these animals the response to either concentrated or iso-osmotic infusions was similar to that observed in normal animals. For these reasons, the more extreme measures for achieving dehydration in the colder weather were employed. These differences in fluid reserve with seasonal changes in temperature are not difficult to understand, inasmuch as the dog's principal loss of fluid by evaporation occurs during panting and this is usually minimal in the colder weather.

#### TREATMENT OF POSTHEMORRHAGIC SHOCK IN DEHYDRATED DOGS WITH ISO-OSMOTIC SERUM OR PLASMA<sup>1</sup>

The clinical response immediately following infusion of iso-osmotic serum or plasma was good in all 9 dehydrated animals studied but it was not as consistent or as striking as that observed in the normal animals (11). Although most of the dogs could stand when removed from the table some were weak and made no effort to walk. Canine serum was used after mild to severe hypocalcemic tetany was encountered in all of the animals which received citrated plasma. In one experiment, a reaction of this nature probably contributed to the ultimate death of the animal. However there was a marked improvement in the condition of nearly all of the animals as soon as the infusions were started. As in the normal group animals which were pulseless and receiving artificial respiration exhibited a cardiovascular recovery and resumed spontaneous respiration within a few minutes of the start of the infusion.

The blood pressure in all of the dehydrated animals infused with iso-osmotic serum and plasma reached maximal levels which were well above shock levels within 10 to 15 minutes, but in none was the recovery as complete or as well maintained as in the normal animals infused with iso-osmotic solutions (11). After the withdrawal of the blood samples for the postinfusion plasma volume determination the blood pressure in most of the dehydrated

animals had dropped 10 to 20 millimeters mercury indicating a greater susceptibility to blood loss after infusion than in the normal animals. Similarly the general condition of some of the animals at the end of the experiment had deteriorated to a certain degree as a matter of fact a few of the animals which died during the night were unable to walk and had to be carried to their cages at the end of the day.

The improvement in clinical condition and blood pressure in general was accompanied by like changes in other experimental data. The circulating time improved in all animals after infusion. The plasma volume was increased considerably in every animal, but in this respect, also the restoration was not as marked as in the normal animals receiving iso-osmotic solutions (11) for in only 5 of the 9 dehydrated animals was the plasma volume after infusion significantly greater than the prehemorrhage plasma volume despite the large volumes of fluid administered. The plasma protein concentration returned to within normal limits after infusion in nearly all animals, but the total circulating protein in those animals which had less satisfactory plasma volume recoveries did not rise above the prehemorrhage values as it had in all of the normal animals which received iso-osmotic infusions.

Excluding the one animal (No. 12) which had a severe tetany and died during the night, the other 3 dehydrated animals with carbon dioxide levels above 15 volumes per cent, like the comparable normal animals (11) all survived more than 24 hours. On the other hand of the dehydrated animals with carbon dioxide levels below 15 volumes per cent 4 died during the night and 1 lived for 17 hours after the infusion. The carbon dioxide recovery after infusion was good in every animal of this group but 1 (No. 18). However in some of these dehydrated animals the carbon dioxide was not of as great prognostic significance as in the normal group. For example in animals Nos. 14 and 17 the recovery of blood pressure circulating time and carbon dioxide after infusion was apparently satisfactory nevertheless, the animals were found dead in the morning.

#### TREATMENT OF POSTHEMORRHAGIC SHOCK IN DEHYDRATED DOGS WITH CONCENTRATED SERUM OR PLASMA

The administration of concentrated citrated plasma (see animals Nos 32, 34, and 38) to dehydrated dogs in shock led to such severe reactions, including sudden death probably from cardiac arrest due to the extreme hypocalcemia, that concentrated serum was used, subsequently. The apparent overburdening of the circulation observed following the administration of concentrated plasma protein solutions to normal dogs (11) frequently occurred in the dehydrated animals, as well. In at least one experiment (No 31), this circulatory embarrassment possibly played a rôle in the death of the animal 45 minutes after the injection for the animal's carbon dioxide level was well above 15 volumes per cent and the expectancy of recovery was good.

As in the normal animals which received concentrated plasma protein solutions (11), the response of the dehydrated animals to concentrated material was slower and less marked than that observed following iso-osmotic infusions in either normal or dehydrated dogs. Even after the blood pressure had reached its maximal levels 15 to 30 minutes after the injection, nearly all of the animals were weak and unable to stand, and some were still comatose. By the time of the post-infusion plasma volume determination, the condition of the animals had improved somewhat, but, in every case, the small amounts of blood required for this determination led to a further deterioration in the animal's condition so that many of the animals were moribund when returned to the cages and died during the night.

The poorer response of the dehydrated animals to concentrated serum or plasma was also disclosed by the laboratory findings. The blood pressure recovery in all animals was delayed, and the maximal level attained was generally lower than that observed following iso-osmotic solutions in both normal and dehydrated dogs, although it was equivalent to that observed following concentrated solutions in normal dogs (11). Moreover, the fall in the blood pressure following the small amounts of blood withdrawn for the final

plasma volume studies was much greater than that observed in any of the other groups.

The plasma volume recovery in the dehydrated dogs following concentrated plasma protein solutions was somewhat better than the clinical improvement and survival times would indicate. The postinfusion plasma volume in all the animals which survived long enough to permit the determination was equal to, or greater than, the initial (prehemorrhage) value in contrast to the normal animals which received four times concentrated solutions.

The arterial plasma carbon dioxide recovery in the dehydrated dogs receiving concentrated solutions was poor in comparison with that of the animals receiving iso-osmotic solutions and there was a better correlation between prognosis and carbon dioxide recovery than in the latter group. Again, the arterial plasma carbon dioxide level at the time of the infusion was important in evaluating survival.

Survival times of the dehydrated dogs receiving concentrated solutions at all levels of arterial plasma carbon dioxide content were poorer than those of the other groups (11). Only 1 of the animals with an arterial plasma carbon dioxide content of more than 15 volumes per cent lived for more than 24 hours, 3 survived the experimental day, and were found dead in the morning, 1 died during, and another shortly after, the injection of concentrated plasma, and 1 lived 45 minutes. Of the animals of this series with arterial plasma carbon dioxide levels below 15 volumes per cent before infusion, only 1 survived the experimental day, 1 died 5 minutes after the injection of concentrated plasma, and 4 survived 3 hours or less.

#### EVALUATION OF STUDY

The influence of dehydration on the genesis and therapy of shock has been mentioned by many reviewers but few experimental investigations of this problem have been reported. Blalock found that deprivation of food and water in unanesthetized dogs led to no change in the average total amount of blood which could be removed by graded bleeding before death. Calvin, on the other hand, observed that dehydrated dogs hemodiluted less than

did normal controls when subjected to severe single hemorrhages which did not produce circulatory collapse.

Our results indicate that the decrease in fluid reserves following water deprivation in dogs has a profound influence on the development and treatment of shock following multiple graded bleedings. The dehydrated animals not only developed a more severe shock after less bleeding but also did not respond as well to either iso-osmotic or concentrated serum or plasma than did the normal dogs (11). More important than this, however, these experiments demonstrate that in dehydrated and in normal animals concentrated plasma protein solutions are definitely inferior to iso-osmotic solutions in the treatment of posthemorrhagic shock. In all degrees of posthemorrhagic circulatory collapse mild to severe the clinical response blood pressure and carbon dioxide recovery resistance to additional blood loss, and survival times of the dehydrated animals receiving concentrated serum or plasma was decidedly poorer than that of dehydrated or normal animals receiving iso-osmotic solutions or of normal animals receiving concentrated solutions (11).

In the last decade the factor of dehydration in the surgical patient has received a great deal of attention from experimental and clinical investigators alike. As a result, the water balance of the surgical patient today is carefully protected both before and after operation. However this achievement of laboratory and clinical science has led some to regard the well hydrated condition of the hospitalized patient as the normal state and to forget that water balance in the surgical patient is not a simple matter which can be adjusted by the rapid administration of large volumes of fluid, at any time. If the patient is to be guarded against the consequences of fluid loss in insensible and visible perspiration, in feces and urine in respiration, and in hemorrhage or exudation during the operation preoperative fluid administration must be started early and continued after operation particularly in patients who can take nothing by mouth. As great as are the fluid requirements of the normal patient the requirements of the dehydrated patient obviously must be

greater. Coller and Maddock for example suggest that at least 7 liters of fluid are needed to correct the fluid balance in a severely dehydrated patient, exclusive of the fluid lost through abnormal channels such as fistulas, internal hemorrhage and such.

More recent experimental studies, moreover have weakened the older concept that the extracellular or interstitial fluid constitutes a protective reservoir of freely moving fluid which must be depleted before any changes occur in the intracellular or the intravascular water. From the work of Hastings and of Peters and their associates there has evolved the concept of the body fluids and solids forming an iso-osmotic system in which semi permeable membranes maintain the solid content of the three phases—intravascular, interstitial and intracellular—with water transfer maintaining an equilibrium and a uniform osmotic pressure in all. Thus, simple dehydration due to water deprivation experimentally should produce an eventual decrease in the total volume and an increase in the concentration of solids in each of the 3 phases.

Hamilton and Schwartz found in dogs that simple water deprivation led to concentration of all body fluids. Mellors and associates (9, 10) reported that in dogs dehydrated by several methods the shifts of fluid were in accord with this concept and that early in dehydration of any type there occurred a decrease not only in the interstitial fluid volume but in the plasma volume as well. Elkinorton and Taffel reported that in dogs dehydrated by deprivation of food and water for long periods progressive hypertonicity of all body fluids developed and a substantial loss of intracellular as well as interstitial fluid occurred with an increased excretion of potassium in the urine. Furthermore Stewart and Rourke have presented evidence that, following hemorrhage in normally hydrated animals, intracellular as well as extracellular fluid is drawn into the circulation. Consequently in evaluating fluid exchanges, it is incorrect to regard 15 per cent of the body weight as freely available interstitial fluid which is readily mobilized to maintain the plasma volume without any influence upon the intracellular fluid.

These considerations are important in any attempt to weigh the potential usefulness of a blood substitute, particularly in war time. The wounded soldier on the field of battle is not the well hydrated patient in the hospital. Under the stress of modern warfare with the widely varying climatic conditions and frequent dislocation of supplies, dehydration of the military or civilian casualty before injury is not uncommon. In addition, the injured may remain untreated in the field for some time, losing fluid and electrolytes in bleeding or exudation from the wound or in vomiting, with resultant oligemia and tissues severely depleted of fluid.

Second, it should be recognized that there are definite limitations to the amount of fluid which can be shifted to the vascular system without seriously affecting the osmotic relations of the interstitial and intracellular fluid, and that these "available" fluids are rapidly depleted by continued bleeding or by dehydration. Our experiments, in normal as well as in dehydrated dogs, demonstrate that concentrated plasma protein solutions, consequently, are not as effective as iso-osmotic plasma protein solutions in the treatment of posthemorrhagic shock, because water cannot be safely withdrawn from the tissues beyond certain limits.

In normal dogs with milder degrees of shock as represented by higher arterial plasma carbon dioxide levels before infusion, the decrease in blood volume and the depletion of the fluid reserves of the body are not too severe so that at times even saline solution will be sufficient to maintain life. In such animals, concentrated plasma protein solutions can sufficiently restore the blood volume without any serious consequences. However, the clinical response, as well as the resistance to further blood loss, is poor in these animals which, after the infusion of concentrated plasma protein solutions, are, in effect, dehydrated animals unless additional fluid is simultaneously or subsequently administered. In normal animals in severer degrees of shock or in dehydrated animals, even in lesser degrees of shock, the decrease in blood volume and in fluid reserves after graded bleeding is more profound so that saline infusions rarely give a

favorable response. In these animals, concentrated plasma protein solutions, although tending to increase the plasma volume, lead to much poorer results than do iso-osmotic solutions, and this is reflected by all the experimental observations—recovery of blood pressure and carbon dioxide levels, clinical condition, survival times, etc. Apparently the increase in plasma volume and the temporary improvement in the circulation which occurs is achieved at the expense of not only interstitial but also of intracellular fluid, with added injury to tissues already damaged by the consequences of the impaired circulation.

The importance of the state of hydration in determining the effects of therapy in shock is illustrated further by the results with iso-osmotic plasma protein solutions in the dehydrated dogs. Apparently the already decreased extravascular fluid reserves in these animals were further depleted by the repeated hemorrhages, creating an extreme tissue dehydration which drew heavily upon the fluid later infused as iso-osmotic serum or plasma. Thus, the plasma volume recovery in these animals was not as good as in the normal animals which received similar infusions at comparable levels of shock, and the other laboratory findings, clinical response, and survival times reflect this discrepancy.

The differences between concentrated and iso-osmotic serum and plasma, in both normal and dehydrated dogs, were especially marked when comparable animals at severer degrees of shock are considered. In making this comparison, we have found that the response to the infusion had a definite relation to one important index of the animal's condition—the arterial plasma carbon dioxide content at the time of infusion—when the hemodynamic criteria of shock, hypotension, and decreased circulation time, were present. Thus, the clinical condition, or the blood pressure, or the circulating time of the animal at the time of infusion could be at "extreme shock levels" but if the carbon dioxide content were above 15 volumes per cent, the probability of the animal's surviving even with saline solutions would be better than if the carbon dioxide content were very low and the other criteria at less critical levels.



That the carbon dioxide content at the time of infusion should give a better index of the degree of shock and the response to infusion is not surprising for unlike blood pressure hematocrit or circulating time which give only an instantaneous picture of the condition of the circulation at a particular moment, the carbon dioxide content is a time intensity factor which measures not only how much, but also how long the circulation has been impaired. Riegal has demonstrated and we have confirmed (6) that following hemorrhage the progressive decrease in arterial carbon dioxide content results from the continued accumulation in the blood of lactic acid and other products of defective tissue metabolism due to tissue ischemia and anoxia. Thus, the carbon dioxide level to a certain extent is a measure of the degree of tissue damage in shock and consequently should be a good index of the response to therapy.

The use of the arterial plasma carbon dioxide content instead of the carbon dioxide combining power as an index of the alkali reserve may be questioned on the grounds that a transient hyperventilation may lead to a lowering of the arterial carbon dioxide content which could be misinterpreted as indicating an increased acidosis. However we have found that, even in unanesthetized dogs, the arterial plasma carbon dioxide content and the plasma carbon dioxide combining power drop almost proportionately as shock develops the combining power of course always remaining somewhat higher than the content. Consequently we have used only the arterial plasma carbon dioxide content because the technical difficulties in the combining power determination make this procedure more time consuming and less accurate than the determination of the arterial plasma carbon dioxide content.

In the treatment of shock the primary consideration is the safety and effectiveness of the

therapeutic agent. Ease and cost of preparation facility of transport and storage speed and ease of administration are all to be considered—and particularly in relation to the widely varying conditions under which the present global war is being waged. However the ultimate decision as to the use of a blood substitute must rest on its safety and effectiveness in the treatment of shock under all conditions encountered in the field. These studies demonstrate that concentrated plasma protein solutions are less effective in the treatment of posthemorrhagic shock in normal as well as in dehydrated animals. Therefore although the use of concentrated solutions presents attractive possibilities and may be satisfactory under certain conditions, isotonic protein solutions appear preferable for routine use and particularly when dehydration may be a factor.

#### REFERENCES

- BLALOCK, A. *Arch. Surg.* 94, 30, 955.
- CALVERT, D. B. *J. Lab. Clin. Med.* 44, 36, 441.
- COLLIER, F. A., and BLALOCK, A. *Can. Surg.* 9, 35, 417.
- ELKINGTON, J. R., and TUTTLE, M. *J. Clin. Invest.* 44, 3, 787.
- GRIGGERS, M. I. and STEWART, J. D. *Am. J. Physiol.* 9, 3, 43.
- GUTHRIE, H., KROGH, H. H., OLSON, W. H., LUTHER, S. O. and NECKELER, H. *War Med.* 14, 334.
- HAMILTON, B. and SCHWARTZ, R. *J. Biol. Chem.* 9, 35, 745.
- HARRISON, A. B. *Harvey Lect.* 44, 194, p. 61.
- MILLON, R. C., MONTGOMERY, T. and MARTZ, F. R. *J. Biol. Chem.* 94, 44, 773.
- MILLON, R. C., MONTGOMERY, T., MARTZ, F. R. and ARNOTT, W. L. *J. Biol. Chem.* 94, 44, 785.
- NECKELER, H., LUTHER, S. O., JOTA, M., WESTON, R. E., and WATSON, C. *Surg. Gyn. Obst.* 94, 77, 337-343.
- PETERS, J. I. *Body Water*. Springfield, Ill. Charles C. Thomas, 1935.
- RIEGAL, C. *J. Biol. Chem.* 97, 74.
- STEWART, J. D. and ROCHER, G. M. *J. Clin. Invest.* 9, 3, 743.
- WESTON, R. E., JOTA, M., LUTHER, S. O. and NECKELER, H. *Am. J. Physiol.* 94, 36, 430.

# WOUND HEALING

## EXPERIMENTAL AND STATISTICAL STUDY

### V —Bacteriology and Pathology in Relation to Suture Material

S ARTHUR LOCALIO, M D, WALTER CASALE, M D, and  
J WILLIAM HINTON, M D, F A C S, New York, New York

**R**ATS are very resistant to infection. Among the several hundred animals that were operated upon with the sterile technique previously outlined, only two gross wound infections were observed. However, since it has been shown (1) that practically all operative wounds are contaminated, usually by air-borne bacteria during the course of an operative procedure, it was thought advisable to determine what percentage of our wounds contained such bacteria. Cultures were performed for aerobic organisms only, since this study is not primarily one of the bacteriology of wounds.

**Catgut** Twelve of the 60 cultures made (20 per cent) of the catgut sutured wounds showed positive cultures. The organisms encountered were *Staphylococcus aureus*, non-hemolytic streptococcus, pyocyanus, and colon bacillus.

**Silk** Four of the 56 cultures made (7.1 per cent) showed positive cultures. Three of the wounds showed *Staphylococcus aureus* and 1 a nonhemolytic streptococcus.

**Wire** Four positive cultures (7.8 per cent) were obtained from 51 cultures made, 2 of which showed *Staphylococcus aureus* and 2 nonhemolytic streptococcus.

**Cotton** Cultures are available in only 43 of the 56 animals in this group. Two positive cultures (4.7 per cent) both containing non-hemolytic streptococcus were obtained.

**Nylon** Four positive cultures of the 55 made, giving a percentage of 7.3 per cent of

the total, were obtained. The organism in all cases was a *Staphylococcus aureus*.

Table XIX presents a summary of the results of the bacteriological study of wounds sutured with the various suture materials.

Organisms were cultured from 20 per cent of catgut wounds, and from 4.7 to 7.8 per cent of nonabsorbable sutured wounds. This marked difference in the incidence of positive cultures we believe is consequent to the more severe inflammatory reaction observed in the catgut wounds. In short, the catgut wounds presented a better medium for bacterial growth. Furthermore, these wounds, because of the marked degree of inflammation present, were not able to cope with bacteria as well as were the wounds sutured with nonabsorbable sutures. This may explain in part the greater percentage of wound infections observed clinically in catgut sutured wounds in comparison with silk sutured wounds (2). Meleney has stated that the most important factor in the reduction of wound infections observed at the Presbyterian Hospital was the change of suture material from catgut to silk.

#### PATHOLOGY

We shall not attempt to describe minutely the gross pathological changes in the wounds since a microscopic examination gives a more accurate appraisal.

#### HISTOPATHOLOGY

**Catgut** Sections made on the 1st post-operative day show slight edema and only small amounts of fibrin. The sutures are intact and there are collections of polymorphonuclear cells about them. Collagen and fibroblasts are not noted and vascular changes are limited to dilatation of pre-existing capil-

From the Departments of Surgery and Pathology of the New York Post Graduate Medical School of Columbia University. This work has been made possible by grants from Mrs. G. Macculloch Miller, Mr. Stewart Hopps and the Surgical Fund of the New York Post Graduate Medical School.

Parts I and II are to appear in International Abstract of Surgery Part III Surgery Gynecology and Obstetrics 1943 77 243-249 Part IV ibid 376-388.



Fig. 2. *Plastic catgut—3 days.* The catgut—in lower center—is surrounded by numerous polymorphonuclear cells. Elsewhere there are numerous polymorphonuclear leukocytes and large quantities of necrotic muscle. The surrounding tissue is edematous, and fibrous is present.



Fig. 3. *Chromic catgut—5 days.* In this photomicrograph there is noted marked polymorphonuclear leukocyte infiltration around the suture. Fibroblasts and lymphocytes are observed in the vicinity but the collagen is lacking.



Fig. 4. *Plastic catgut—4 days.* There is present much fibrous here, but the fibroblasts and the collagen are, for the most part, of young type. The dark, fragmented area represents numerous polymorphonuclear leukocytes and moderate number of red cells.

lanes. Small scattered areas of necrosis with collections of polymorphonuclear cells about them and small abscess formations are seen, limited for the most part to the muscle.

On the 2d postoperative day the sutures are intact with small abscesses about them. Collagen is not present. One section shows a minimal number of young fibroblasts. Previously existing capillaries show moderate en-

TABLE XIX.—POSITIVE WOUND CULTURES IN RELATION TO SUTURE MATERIAL<sup>1</sup>

Suture material	No. of animals	No. of cultures taken	Positive cultures		Organisms recovered
			No.	Per cent	
Catgut	66	66		20	Bacillary leucococci aureus, and hemolytic streptococci, 17 organisms, other bacilli
Ich	26	26			Bacillary leucococci aureus, and hemolytic streptococci
Cotton	26	42			Nonhemolytic streptococci
Silk		21			Bacillary leucococci aureus, and hemolytic streptococci
Keloid	12	11	5	7.3	Bacillary leucococci aureus

<sup>1</sup>Table is 20 as in previous report.



Fig 4 *Plain catgut—13 days* The compact fibers are surrounded by an edematous, vascular granulation tissue in which many fibroblasts and much of the collagen are of the young type. Adult types of each are also present. There are numerous lymphocytes and histiocytes.



Fig 5 *Chronic catgut—31 days* The granulation tissue by which the catgut is surrounded is composed for the most part of adult fibroblasts and strands of dense collagen. It is moderately vascular, and numerous histiocytes and a moderate number of lymphocytes are present. A few polymorphonuclear leucocytes are present in between the fragments of the suture material.

gorgement. Only a small number of chronic inflammatory cells are noted. Scattered abscesses are present, and there are areas of necrosis in the muscle and fascia.

On the 3d day sections show a minimal degree of edema. Small amounts of fibrin are present. There are large collections of polymorphonuclear cells about the sutures. Some young fibroblasts are seen, and collagen is young and slight in amount. In one section (205) a few thick strands of mature collagen are noted and capillary buds are seen in the area of fibroplasia. Elsewhere only a few capillary buds are noted, and pre-existing capillaries are only slightly dilated. Some chronic inflammatory cells are present. Scattered small abscesses, small areas of necrosis in the muscle and fascia and a few focal hemorrhages are observed.

On the 4th day edema is marked and larger amounts of fibrin are present. Beginning fragmentation of the sutures is noted with abscess formation about them. Some young fibroblasts are seen, collagen production is minimal, and the collagen is immature. As-



Fig 6 *Chronic catgut—63 days* The fragments of suture material are surrounded by fibroblasts, lymphocytes and histiocytes. Collagen is of the dense adult type.



Fig. 7. *Silk—3 days.* The suture material—dense black strands—is embedded in an area of moderate edema and lymphocytic infiltration. The fibroblasts are for the most part of the young type, and there is scanty collagen present.



Fig. 8. *Silk—5 days.* Here, the silk represented by the black homogeneous material and the dense defect, is flanked by both young and mature fibroblasts, numerous lymphocytes, few leukocytes, and scattered capillaries. Much of the abundant collagen is of the adult type.

cularity is moderate and capillary buds are forming. There is a diffuse infiltration of chronic inflammatory cells, and there are some large mononuclear cells. The acute inflammatory process is diffuse and there are many abscesses and areas of necrosis. A few small focal hemorrhages are present. In wounds sutured with chromic catgut a number of young fibroblasts and a few mature fibroblasts are present. Collagen is a little more abundant and a few areas of maturing collagen are noted.

On the 5th day a number of mature and young fibroblasts are present. Young and mature collagen is present in about equal amounts. Many new capillaries are seen. Chronic inflammatory cells are diffuse throughout all sections. Acute inflammatory reaction and many small abscesses are seen. There are scattered small areas of necrosis, particularly in the muscle and a large area of necrosis about one suture. In the reactive areas small focal hemorrhages and thrombosis of small blood vessels are noted. In the chromic catgut sutured wounds the number of mature fibro-

blasts is greater and strands of collagen are beginning to appear.

Suture material on the 6th day is largely fragmented; there are a few polymorphonuclear cells with little fibrin and a few mature fibroblasts about it. Fibroplasia is increasing. The majority of the fibroblasts are young and immature. Collagen is present in moderate amounts and is mostly precollagen although some is mature collagen. Many young capillaries are noted. Chronic inflammatory cells infiltrate the wound. A few small necrotic areas are seen, surrounded by small abscesses.

By the 7th day only small fragments of suture material remain, surrounded by collagen and young fibroblasts. Fibroplasia is marked and the majority of the fibroblasts are mature. Collagen is abundant, mature and arranged in bundles. Vascularity is marked. Chronic inflammatory cells are seen throughout all sections. There are abscesses about small areas of necrosis in the muscle and about the suture fragments.

On the 8th day edema is slight and only small amounts of fibrin remain. Sutures are



Fig 9 *Silk—8 days*: Suture material is invaded and surrounded by numerous fibroblasts, many of adult form. The collagen is dense. Numerous lymphocytes, a few histiocytes, some giant cells are present. There are fibroplastic invasion of bundle of silk and some altered muscle in upper right



Fig 10 *Silk—45 days*: Many of the fragments of suture material in this section are engulfed by giant cells, and the entire area is invested by fibroblasts and some lymphocytes. A few dense strands of collagen are seen throughout the area

present only as fragments, with a collection of polymorphonuclear cells and fibroblasts about them. Some mature fibroblasts are present, collagen is mostly adult, marked in quantity, and bundles are frequent. Vascularity is decreasing, and acute and chronic inflammatory cells are diffuse throughout the sections. Necrosis is slight in the muscle and abscesses are not seen.

The picture on the 9th day is similar to that on the 8th, except that collagen is more dense. Areas of necrosis and small abscesses are seen.

By the 13th day edema and fibrin have disappeared. Only small fragments of suture material remain, more plentiful in the chronic section than in the plain. Giant cells and fibroblasts are seen about the sutures. Fibroplasia is marked and the fibroblasts are adult. Collagen is dense and mature. Chronic inflammatory cells are fewer in number and the acute inflammatory process has subsided except for scattered minute abscesses associated with residual necrosis in the muscle.

On the 21st, 31st, 45th, and 62d days

edema, fibrin and suture material are not recognizable. Fibroblasts are old, collagen is dense and mature. A few old capillaries are seen, and the acute and chronic inflammatory reaction has completely subsided. In chronic catgut sutured wounds, however, a few fragments of suture material remain with small collections of polymorphonuclear cells about them. There is also a diffuse chronic inflammatory reaction and large phagocytes may be seen about the sutures.

*Silk* Free serum was rarely seen in silk sutured wounds. Occasionally, some fibrinopurulent exudate was seen along the suture line.

On the 1st postoperative day, sections showed some edema and fibrin. Polymorphonuclear cells are seen around the suture and in one section a small abscess is present. Fibroblasts and collagen are absent with the exception of a few young fibroblasts in one section. The old capillaries are moderately dilated. Acute inflammatory cells are present only about the suture material, and a few scattered chronic inflammatory cells are



Fig. 11—54. The bit space represents the tissue defect left behind by the removed suture. About 4, the fibroblasts are of the young type, as is the pale, light pink fibrillar collagen. A few lymphocytes and histiocytes are present. There are plump, mature fibroblasts (young) and early collagen (pale, fibrillar, light pink) but no acute reaction.

noted. Small areas of necrosis are seen in juxtaposition with the incision and in one slide an area of necrosis is seen in the muscle. There are a few scattered hemorrhages.

On the 2d day a few young fibroblasts and some immature collagen are seen in all the sections. Vessels are engorged, and a few young capillaries may be seen. Acute and chronic inflammatory cells are scattered throughout the section. An increased number of polymorphonuclear cells are seen about the suture and in the small necrotic areas in the muscle. No abscesses are in evidence. Scattered hemorrhages are present.

Sections on the 3d postoperative day show that the suture material is beginning to split. A few polymorphonuclear cells are seen about and among the strands of the suture material. A few immature fibroblasts, some immature collagen and a few young capillaries are noted. In the case of animal No. 340 fibroplasia and collagen formation are more marked. A hematoma is present and in this area there is a collection of polymorphonuclear

cells and some muscle necrosis. Wounds in other animals show only a few chronic and acute inflammatory cells and scattered areas of muscle necrosis.

The 4th day shows invasion of the suture by a few young fibroblasts, most of them immature. Collagen is practically all immature although some maturing islands are noted. A number of young budding capillaries are seen. There are no abscesses and chronic and acute inflammatory infiltration is slight. A few scattered hemorrhages and small areas of muscle necrosis are noted.

On the 5th day section shows the suture material invaded by chronic inflammatory cells including a few giant cells. A few polymorphonuclear cells are seen about the suture material and invasion by young and mature fibroblasts is well under way. A considerable amount of mature collagen and many capillaries are seen. Acute inflammatory reaction is slight and no abscesses are seen. In the case of animal 343 muscle necrosis is marked and here polymorphonuclear cells have gathered. There are some very small hemorrhages.

By the 6th day fibrin is no longer recognized. The suture material is invaded by many fibroblasts, most of which are mature. Mature collagen is present but most of it is intercellular and hands have not yet started to form. Chronic inflammatory cells and a few giant cells are present. Only a few polymorphonuclear cells are noted and there are no abscesses, necrosis or hemorrhage.

Sections on the 7th postoperative day show that large numbers of fibroblasts have surrounded and infiltrated the suture fragments. Fibroplasia has increased and the majority of the cells are mature. Mature collagen is present in large amounts and in some areas is arranged in dense bundles. Vascularity is mild and only a few acute and chronic inflammatory cells are seen. There are no abscesses, areas of necrosis or hemorrhage.

The 8th and 9th days present a similar picture except that more giant cells are noted, and there are fewer chronic inflammatory cells. Collagen is present in dense strands the fibroblasts are mature.

From the 13th to 21st day only few chronic inflammatory cells are seen. Scars are dense







Fig. 3. Catgut—1 day. There is small collection of polymorphonuclear leucocytes adjacent to the suture. The tissue about the catgut is moderately edematous, diffusely infiltrated with few polymorphonuclear leucocytes and moderate number of lymphocytes, and vascular. The fibroblasts are of the young type, and the collagen is rather scanty in amount, and of the pale, fibrillar young form.

diffuse infiltration of chronic inflammatory cells and in two sections a few fibroblasts of the young immature type.

On the 3d day many young fibroblasts are noted and some immature collagen. New capillaries are present. Chronic inflammatory cells are diffuse throughout the sections particularly in areas with engorged channels believed to be dilated lymphatics. Acute inflammatory cells are restricted to the areas containing the sutures and surrounding several small areas of necrosis in the muscle. Here small focal hemorrhages are found.

On the 4th day only a few polymorphonuclear cells are seen and young fibroblasts surround the sutures. Collagen is abundant and for the most part immature. Some young capillaries are seen. Chronic and acute inflammatory cells are few and diffusely arranged. No abscesses or areas of necrosis are seen. In one section (118) there is a hemorrhagic area, greater edema and deposition of fibrin, fewer fibroblasts and less collagen.



Fig. 11. Catgut—5 days. There is very little acute reaction. Fibroblasts are equally divided between young and old forms. Collagen is scanty but nearer the mature type of collagen. There are few lymphocytes and leucocytes.

Sections on the 5th postoperative day show large numbers of fibroblasts surrounding the sutures and among the strands. Fibroplasia is greater and an increasing number of mature cells are seen. Strands of mature collagen are discernible in many areas. Some young capillaries are noted. A few chronic inflammatory cells and a few polymorphonuclear cells are scattered throughout. In one section (259) a small abscess is seen surrounded by excessive edematous granulation tissue and many polymorphonuclear cells. A few minute focal hemorrhages are present.

On the 6th and the 7th days the picture is similar to that on the 5th day except that fibroblasts are mature and collagen is abundant and dense. Section 252 shows a central abscess surrounding necrotic muscle. On the 7th day section 112 shows a large abscess about an area of necrotic muscle surrounded by edematous granulation tissue and many polymorphonuclear cells.

On the 8th day the sutures are surrounded and invaded by fibroblasts. No inflammatory cells, edema or fibrin, are present. A few im-



✓ Fig 15 *Cotton—13 days* Here, not only the entire suture, but each individual fiber is invested by adult fibroblasts and foreign body giant cells. Lymphocytes and histiocytes are also present. Acute reaction is minimal. Collagen is of the adult type, although not yet as dense as seen in older sections.



Fig 16 *Cotton—31 days* Each fiber is surrounded by fibroblasts, and relatively numerous lymphocytes and histiocytes. A few giant cells are present. Collagen is scanty, and consists of a few dense fibers. No acute reaction is present.

mature types of fibroplasia persist. Collagen is dense, of the adult type, and laid down in strands. Some chronic inflammatory cells and a few foreign body giant cells are diffused throughout. Acute inflammatory reaction is very slight.

By the 13th day the sutures are seen to be embedded in fibroblasts, and a few chronic inflammatory cells and giant cells are seen surrounding them. There is no evidence of acute inflammatory reaction. Section 240 is overrun with polymorphonuclear cells showing edema. There are numerous young capillaries and the blood vessels are dilated.

On the 21st day, fibroblasts, although adult and abundant, are not as dense as might be expected at this stage. Foreign body giant cells are seen about the sutures.

By the 62d day dense strands of collagen have formed. There is no inflammatory reaction. Foreign body giant cells are present about the suture material.

*Nylon* Sections from nylon sutured wounds on the 1st postoperative day show edema and

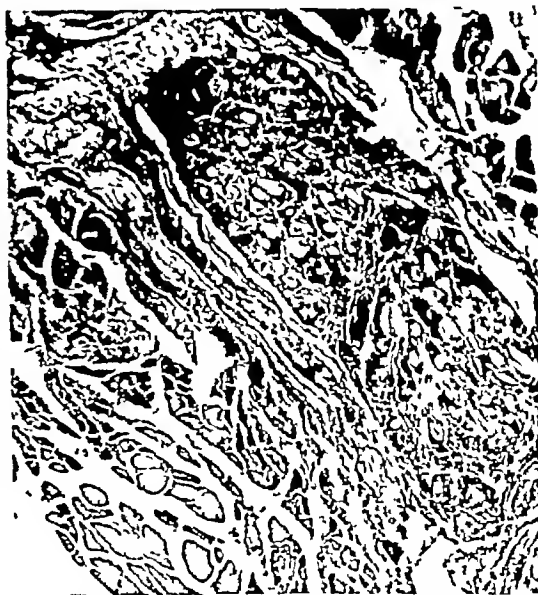


Fig 17 *Cotton—62 days* There is a compact mass composed of cotton fibers, each of which is ringed by fibroblasts and dense collagen. Histiocytes and lymphocytes are sparsely scattered about and a few giant cells are present.



Fig. 8. Yslen—4 days. In this specimen there is noted marked edema, much fibrin, few necrotic muscle fibers, and moderate number of polymorphonuclear leukocytes.

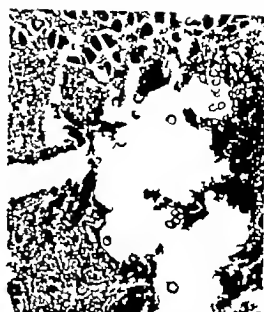


Fig. 9. Yslen—5 days. There is collection of polymorphonuclear leukocytes near suture material. Nearby tissue is edematous, muscular and the fibroblasts are of both young and adult form. Collagen is scanty, fibrin present.

deposition of fibrin. A few polymorphonuclear cells surround the suture material. Some acute and chronic inflammatory cells and several small hemorrhages are present.

On the 3d day edema and fibrin deposition have increased. Collagen and young fibroblasts are not seen. A few capillary buds are present. A few chronic inflammatory cells are scattered throughout and acute inflammatory cells are present in small groups surrounding small areas of necrotic muscle forming small abscesses.

On the 3d day some young fibroblasts and capillaries are seen, and a small amount of young collagen is present. There are a few chronic inflammatory cells and a few polymorphonuclear cells about the suture material. Section 382 shows more collagen and more advanced fibroplasia. On the 4th day sections show scattered focal hemorrhages. Many areas of muscle are altered although not necrotic.

Edema has decreased by the 5th day. Fibroblasts and collagen are more abundant and maturing. Fibroblasts are seen around and in the strands of the suture material.

On the 6th day mature collagen is laid down in thick strands. In animals 391 and 376 there are areas of muscle necrosis with abscess formation surrounding them. Animal 376 also shows a distinct retardation of fibroplasia as compared with other animals in this group.

By the 7th day edema has practically subsided although fibrin fragments are still recognized. The sutures are embedded in fibroblasts which are abundant and of the adult type. Collagen is laid down in dense mature strands. A few adult capillaries are present. Chronic inflammatory cells are scattered. The acute inflammatory reaction has subsided and only a few polymorphonuclear cells are noted. Areas of regenerating muscle are seen.

On the 9th day the scars present mostly mature fibroblasts and thick bands of mature collagen. Animal 358 shows a cavity filled with granulation tissue and containing a small number of polymorphonuclear cells. By the 13th day the inflammatory reaction and edema have subsided. The scar is adult in type and cellular. By the 62d day the scar is contracting and is less cellular. The suture



Fig 20 Nylon—5 days The bundle of nylon is well surrounded by fibroblasts, many of which are of the adult type The collagen is abundant, and much of it, while not dense, is well on its way to the adult form Lymphocytes and histiocytes are slight to moderate in number, and a few capillaries are present. There is slight edema ✓



Fig 21 Nylon—8 days The collagen is relatively abundant and dense, the few fibroblasts are of the adult or slightly younger type There are a few lymphocytes, histiocytes and foreign body giant cells Edema is present but is only slight. There is very little inflammatory reaction ✓

material is embedded in scar tissue and a few giant cells are seen surrounding it

#### SUMMARY

Grossly, little difference was observed among wounds sutured with nonabsorbable materials Serum was not seen in large amounts in cotton, silk, wire, or nylon sutured wounds Furthermore, it was unusual to find serum in the subcutaneous tissues after the 3d or 4th day in animals whose wounds were sutured with nonabsorbable material

Catgut sutured wounds, on the other hand, contained serum in varying amounts up to the 9th day The wounds were pale, and a fibrinopurulent membrane was present along the fascial and peritoneal suture line between the 2d and the 7th day Very few of the wounds sutured with nonabsorbable material showed this membrane and only between the 2d and the 4th day

Microscopically, marked differences are seen between catgut sutured wounds and those sutured with the nonabsorbable ma-

terials Catgut wounds show edema for longer periods of time and maturation of fibroblasts and collagen is retarded (Figs 1, 2, 3, 4, 5, 6) The most significant difference is in the inflammatory reaction In catgut wounds it is acute, intense, prolonged, and associated with widespread death of tissue and abscess formation

Among the wounds sutured with nonabsorbable materials, no significant histopathological differences were noted Fibroplasia, collagen formation, and maturation are practically the same in the case of all materials (Figs 7 to 21) In silk and cotton sutured wounds the inflammatory reaction is somewhat more intense and prolonged than in the case of nylon and wire sutured wounds (Figs 7, 8, 9, 10, 13, 14, 15, 16, 17) Healing occurs at about the same rate Studies of tensile strength agree with these observations

Little difference in tensile strength was observed between wounds sutured with plain catgut and those sutured with chromic catgut, although mature fibroblasts and collagen

were noted 1 day earlier in chronic catgut sutured wounds.

It is of interest to note that fragments of chronic catgut are observed in wounds at the end of 2 months and that an inflammatory reaction is still present about the suture material at this time (Fig. 6). Wounds sutured with nonabsorbable sutures also show the material present at the end of 2 months but it is fragmented and encapsulated by fibroblasts, and shows evidence of a foreign body reaction (Fig. 17).

Two factors are apparently responsible for the prolonged lag period in healing observed in catgut sutured wounds: first, the marked destruction and acute inflammation (Figs. 1 to 6) which necessitate a prolonged period of

débridement; second, the delay in the maturation of fibroblasts and collagen, due probably to acute inflammatory reaction. The delay in final healing of catgut sutured wounds, as noted in studies of tensile strength, and also microscopically, must be attributed to the more widespread destruction and acute inflammation of tissues in these wounds.

#### REFERENCES

1. IVER, H. R., JR., and HINESFIELD, J. W. *Ann. Surg.* 93B, 97, 607.
2. MILENEY, F. L. *Surg. Gyn. Obst.* (Internat. Abstr. Surg.) 940, 7, 432.
3. VIVIER, P. The bacteriology of colostomy wounds sutured with catgut and silk. (Part of thesis presented to Columbia University for Degree of Master of Medical Science, 1934.)

# HORIZONTAL PIN FIXATION FOR FRACTURES OF MANDIBLE USING PIN GUIDE

DOUGLAS F. PINCOCK, D D S, Major, D C, A U S, Ogden, Utah

MANY professional articles as well as those for the layman have been written concerning fracture appliances which permit function during healing. It is a recognized fact that normal physiological function must be limited to some degree. However, any use that can be made of a reduced fracture during treatment is a distinct advantage.

There have been many methods of treating fractures of the mandible, all having advantages and disadvantages. Interdental immobilization by wiring is a simple method, quickly applied, but does not permit mandibular motion or facilitate good oral hygiene. The use of intraoral splints permits mandibular motion but prevents proper cleansing of the area involved. Extraoral appliances (Stader splint) is not the answer to most civilian fractures because cleansing and caring for the face is very difficult under this appliance. There are many advantages in its use, however, particularly in cases in which there has been a loss of bone (war wounds), and it is desired to maintain space, limiting the deformity and simplifying the reconstructive surgery.

It was in an effort to find some means of fracture fixation that would permit mandibular motion and good hygiene that the horizontal pin method was devised. This procedure consists of one or two pins (Kirschner wire, large) drilled horizontally through the body of the mandible, across the fracture with both ends of the pin imbedded in the cortical bone. The wire can be cut short and the skin raised over the end, leaving no external evidence of the fixating pin.

This type of fracture immobilization permits normal physiological mandibular function. The patient is able to continue with his work, carry on a regular routine of life, being limited only to a liquid or soft diet.

After having drilled a few of these pins in the mandible, one is soon convinced of the necessity of some type of a pin guide. I designed and had Jack Pava, brace mechanic at Hoff General Hospital, make the pin guide shown in Figure 1. The tube *AD* directs the wire to point *B*. This device eliminates the guesswork and hazards of freehand drilling.

The technique used is as follows. A minimum of loop wires is applied to the upper and lower teeth. Intermaxillary rubber bands are used to re-establish proper occlusion and alignment of the fragments. This is a very important step. If normal interdental relation is not correctly established, the resulting malocclusion will produce traumatic pressures with the resulting loosening of the pin and possible failure of union. Block anesthesia is used with local infiltration in the region of the symphysis and posterior border of the mandible. The pin guide is applied by first inserting the point *B*, Figure 1, into the posterior border of the mandible. The point of the guide tube (*A*, Fig 1) is then positioned into the area lateral to the symphysis. The wing pin (*C*, Fig 1) is then tightened as the pin guide is rotated on its axis (*AB*, Fig 1). These points are so beveled that they will drill themselves into the cortical bone. When the pin guide is firmly clamped into position, posteroanterior, and lateral jaw x-ray films are taken. This permits checking the position of the director before the pin is drilled into the mandible. The pin is then screwed out of the tube at *D*, Figure 1, and the large Kirschner wire is run through the directing tube and drilled into position. It is necessary to disassemble the two halves of the clamp by releasing the wing pin to remove it from its position. Digital examination is then made to find the posterior end of the pin. If it cannot be located the drilling is continued until the end can be felt just through the posterior border of the ramus. The pin is cut short

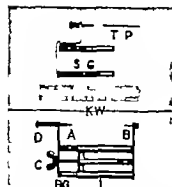


Fig. 1



Fig. 2



Fig. 3

Fig. 1 and 2. Thromb out and pin which has removed opens tube D. I C lag bolt for clamp adjustment, B-G and mandibular body guide (see Fig. 3) S-G substituted for B-G with makes symphysis guide (see Fig. 3) K W Kirschner wire (surge).

T P threaded pin (stainless steel) 20 by 3 mm  
Fig. 4 The body guide applied to the mandible (inferior view).

Fig. 5 Symplysis guide applied to mandible (inferior view).

enough to permit pulling of the skin and subcutaneous tissue over it. A small dressing is applied over the anterior and posterior pin holes in the skin and removed in 2 or 3 days. The mandible is subsequently roentgenographed to check the pin position and then the interdental wires and rubber bands are removed. If it is felt that additional support is necessary to prevent rotation of the fragments, a figure of eight wire can be applied to the teeth on either side of the fracture.

The pin can be removed in about 6 weeks under local anesthesia. The end of the pin is located by digital examination, and about 1 cubic centimeter of 2 per cent procaine is infiltrated into the area. The operator makes a small stab incision feeling the end of the wire with the scalpel. The surrounding tissue is compressed until the end of the pin extends through the incision. It is grasped in a heavy plier and withdrawn by a rotating motion.

It has been rather surprising how firmly the pins have been held in position, and at times they require considerable turning to free them.

A series of twelve completed cases have been treated in this manner at Hoff General Hospital, U S Army. We have had no infections, and all have healed with excellent results. The patients have been very comfortable during treatment and a casual observer would not know they were being treated for mandibular fractures. In fact I have had 2 patients ask for this form of treatment. They were patients with interdental wiring applied at their station hospitals, then transferred to our hospital and were able to observe this type of fixation on other patients in their ward. When patients ask for it the factor of comfort must be of some importance.

CASE. C. A. age 30 years, diagnosis, fracture of the mandible ununited, oblique region of the right symphysis, with overriding edentulous fragments. Injury sustained in automobile accident 3 years prior to entrance into military service. General anesthesia—nitrous oxide oxygen and ether was used. Closed reduction was carried out. A incision was made along the inferior border of the mandible over the fracture site and the periosteum was reflected from the fragments. The ends (table) were freshened by means of an electrically driven circular saw. The fragments were then approximated and held in position by two crossed horizontal pins (threaded of stainless steel). The periosteum and subcutaneous tissue are approx-



Fig. 4 and 5. Case



Figs 6, 7, 8, 9, from left to right Case 2



Figs 10, 11, 12, from left to right Case 3

mated with catgut, the skin was sutured with 50 silkworm gut (Figs 4 and 5)

This patient had an uneventful recovery. The pins were removed 8 weeks after operation under local anesthesia. The fragments were healed in excellent position, and the patient was returned to full duty.

**CASE 2** K E J, aged 29 years, diagnosis fracture of mandible, compound, comminuted, complete, bilateral, regions of left 1st molar and right 3d molar, accidentally incurred during supervised athletics.

The anesthesia was produced by mandibular block, with local infiltration. A minimum of looped wires was applied to the teeth, and intermaxillary rubber bands were used to re-establish the occlusion and alignment of the fragments. The pin guide was applied and adjusted into position. A large Kirschner wire was drilled horizontally through the body of the right and left mandibles. A figure-of-eight wiring was applied to the teeth, left, 1st and 2d bicuspids and 1st molar, to aid in preventing rotation of the fragments (Figs 6, 7, 8).

This patient had an uneventful recovery. The pins were removed in 6 weeks, and the soldier returned to full duty.

**CASE 3** P S I, aged 22 years, diagnosis fracture of the mandible, compound, comminuted, complete, unilateral, region of the left 2d molar. The fracture was sustained during a fight with another soldier.

Mandibular block, with local infiltration anesthesia was used. Occlusion was re-established and the fragments were realigned by the use of the loop method, with intermaxillary rubber bands. A

Kirschner wire was drilled from the posterior border of the ramus anteriorly, making its exit on the lateral surface of the mandible in the region of the mental foramen. The wire was directed in this position by inserting point A, Figure 1, of the pin guide, into the posterior border of the ramus, and point B, Figure 1, held into the lateral surface, just above the inferior border, in the region of the mental foramen. This mandible was oval in shape, the patient's face being very round, making it impossible to drill the wire from the symphysis to the posterior border of the ramus (Figs 10, 11, 12).

There were no complications, and the pin was removed 6 weeks after operation, under local anesthetic. He was returned to full duty the following week.

**CASE 4** A T S, aged 19 years, diagnosis fracture of the mandible, compound, comminuted, complete, unilateral, region of the left 1st molar. Patient was injured when he was struck on the jaw by a civilian. The anesthetic used was mandibular block, with local infiltration. Occlusion was re-established by the loop method and intermaxillary rubber bands. The pin guide was applied, and a Kirschner wire (large) was drilled horizontally through the body of the mandible, extending from the left symphysis to the posterior border of the ramus (Figs 13, 14, 15).

The pin was removed in 6 weeks, and the soldier was returned to duty 4 days later. There were no complications during treatment of this case.

The method of treating fractures of the mandible was thought to be new and was so demonstrated at the October 19, 1942, staff





Figs. 3, 4, 5, from left to right. Case 4.

meeting of the Hoff General Hospital, U S Army. However articles were later found dating the treatment as early as July 9, 1932 (2) and Sobye (4) published a series of 25 cases in 1939. This treatment was also reported by Meade (3) in 1935 and Brown (1) in 1942.

These articles have all reported a tendency of the pin to loosen after operation. This has not been the experience at this hospital. The pins removed 6 weeks after operation seem to offer about the same resistance as those which were removed for redrilling. If the pin is confined to the intermedullary bone the loosening is negligible. The pictures demonstrated in the articles by Ipsen, Meade, and Sobye give one the impression that the pins have been drilled from the right to the left mandibles, across the floor of the mouth. It is possible that the muscle traction in the floor of the mouth accounts for the reported loosening of the pin.

The question might well be asked: What will happen to the mandibular nerve if the pin is drilled into the canal? An effort is made to place the pin below the canal, but if the Kirschner wire should enter it, I believe it to be of no importance. The wire is smaller in diameter than the canal and as the pin passes through the canal, the nerve will be pushed aside causing little or no damage.

It is very difficult to judge the trauma associated with drilling the pin in the canal because of the anesthesia usually present with mandibular fractures. In the series of patients treated at this hospital it has been impossible to observe any change in the degree of anesthesia. Four of the postoperative

x-ray films have shown the pin and mandibular canal in contact. However one must keep in mind that the pin could be placed in a position medial or lateral to the canal, and the shadows superimposed. Therefore the pin may or may not have been drilled into the canal.

#### CONCLUSION

Positioning the horizontal pin or Kirschner wire (large) through the mandible requires accurate drilling. The pin guide will direct the wire into only one position, points A and B, Figure 1. Therefore the success in positioning the pin correctly depends upon the proper adjustment and alignment of the guide.

#### ADVANTAGES

The comfort of the patients is a paramount factor. They are able to keep their mouths clean, to eat without the laborious effort of sucking everything through their teeth, and to speak distinctly. In other words, the patient has normal physiological mandibular motion, being limited only to a liquid or soft diet. There is no external appliance to interfere with the cleaning of the face and to detract from the appearance of the patient.

The only disadvantages of this method compared to intraoral immobilization, is that this procedure must be done aseptically and requires an operating room to carry out the technique.

#### REFERENCES

1. Brown, ed McDowell, *Surg. Gyn. Obst.* 1942, 74: 27.
2. Ipsen, *J. Clin. Chir.* 1932, 60: 310.
3. Meade, *H. Trans. J. M. Soc.* 1935, 1: 1.
4. Sobye, *Paul. Acta Chir. Scand.* 1939, 83: 445.

# PROTRUDED INTERVERTEBRAL DISKS

J GRAFTON LOVE, M D , F A C S , and MAURICE N WALSH, M D , Rochester, Minnesota

**I**NTERVERTEBRAL disks are the fibrocartilaginous shock absorbers that normally are placed between the bodies of the movable vertebrae of the spinal column. By protrusion of a disk we mean an abnormal posterior displacement of a portion of that disk. We believe that this, to be of significance, has to be associated with a fragmentation of the fibrocartilage. That is, the continuity of the disk is interrupted and one or more fragments are displaced posteriorly so as to be capable of causing undue stretching or tearing of the posterior longitudinal ligament which forms the anterior wall of the spinal canal. In addition to the abnormal pressure on, or rupture of, this ligament there is usually associated intraspinal irritation of, or pressure on, nerve roots if the lesion is in the lumbar portion of the spinal canal or pressure on the roots or the spinal cord itself if the lesion happens to be in the cervical or thoracic portion of the spinal canal.

Although protruded intervertebral disks as such have been recognized and their clinical importance has been established only since the excellent work of Mixter and Barr, the condition was found occasionally at operation when patients were subjected to laminectomy for a supposed intraspinal neoplasm as long ago as 1922, when Adson encountered several of the lesions and considered them to be primary cartilaginous neoplasms or enchondromas.

Goldthwait, Adson, Dandy, Stookey, and others have contributed to our knowledge of this condition. In 1936 one of us (Love, 6) introduced the term "protruded intervertebral disk" as most appropriate for the condition. This designation has since been accepted by the *Journal of the American Medical Association* and by Dr. Mixter as quite satisfactory.

Today this lesion is accepted as a distinct clinical and pathological entity and all up-to-date textbooks of orthopedics and neurology should include a discussion of the condition.

## ANATOMY OF THE INTERVERTEBRAL DISKS

The intervertebral disks are fibrocartilaginous cushions which are placed between the vertebral bodies. They are bounded anteriorly by the anterior longitudinal ligament and posteriorly by the posterior longitudinal ligament. The intervertebral disks are applied to the surfaces of the cartilaginous plates which cover the bony vertebral bodies and normally they do not extend beyond the margins of the vertebral bodies. Under conditions of normal stress and strain they bulge slightly beyond these limits, but when the force exerted against the vertebral column or on it is no longer acting, the normal disk returns to its normal confines. The disk is composed of two structures: a central, loose, semigelatinous nucleus pulposus, in which is represented the remnant of the fetal notochord, and an outer, firmer, more fibrous annulus fibrosus.

## PATHOLOGY AND ETIOLOGY OF PROTRUDED DISKS

As a result of our studies and those of Deucher and one of us (Love, 4) it is our opinion that the protruded portion of an intervertebral disk practically always consists of both nuclear and annular material. This is one of the reasons why we have adopted the term "protruded disk" as being more applicable than some of the others, such as herniated or extruded nucleus pulposus, rupture of the intervertebral disk with herniation of the nucleus pulposus, and so forth.

The protruded portion of the disk may show various degrees of degeneration and fragmentation, and the fragments may be very edematous at times. In the opinion of Deucher and one of us (Love, 4) this is due to a vascular change and this conclusion is supported by the fact that the nucleus pulposus is capable of increasing its volume many times when freed of the restraining influence of the annulus fibrosus.

It has become generally recognized that the protrusion of an intervertebral disk is often

From the Sections on Neurologic Surgery and Neurology, Mayo Clinic.

preceded or accompanied by unusual stress or strain to the back. We have come to look on the condition as being definitely due to trauma. The injury may be relatively mild or severe. It may be direct or indirect. It is most often associated with the lifting of unusually heavy objects and the symptoms in their classic form may be sudden in onset or more or less gradual in their development. That there are predisposing factors we cannot deny but as yet there is no really clear-cut understanding of what they may be.

#### HISTORY TAKING IN CASES OF SUSPECTED PROTRUSION OF AN INTERVERTEBRAL DISK

In all diagnoses the patient's history constitutes one of the most important portions of the examination. This is particularly true in neurology and especially so in the diagnosis of protruded disk. The patient should be allowed to relate the story of the development and the progress of his disease. Leading questions should be avoided, particularly in dealing with patients who present a medicolegal problem and those of unstable or neurotic disposition. An occasional pertinent and pointed question while the patient is relating his story will serve to elucidate important points and to avoid an unnecessarily long record. There are several very important questions the answers to which should be obtained in the course of the history taking.

The patient's occupation and the type of work he usually does should be understood. Likewise some information regarding his hobbies should be elicited. This is particularly true of golfers, hockey players, campers, canoeists and horseback riders.

Did the pain—and pain is the cardinal symptom of protruded disk—of which the patient complains come on after an injury to the back, direct or indirect, after unusual lifting or stretching or being caught with the back twisted or in an awkward position? Had the patient been subject to backaches or "lumbago" before the onset of sciatic pain or pain of a lower extremity and did the sciatic pain come after unusual stress or strain. Is the pain constant or intermittent—and what, if anything will give relief and what will aggravate it? The effect of coughing, sneezing and

straining at the stool should be determined. The results of various treatments, which the patient has usually tried should be elicited. If scoliosis is not present at the time of examination the history of listing and particularly of alternating listing of the trunk is very important. The presence or absence of paresthesias in the distribution of the pain should be determined also. The patient should be asked as to his habits of sleep. If his sleep is disturbed by pain the fact is significant. Twenty-seven per cent of 732 lumbar protrusions produced pain at night. It must be determined that the pain awakens the patient from his sleep rather than that for some other reason he wakes during the night and then becomes conscious of the fact that he is uncomfortable. Likewise the history of loss of weight is important. Loss of weight is usually associated with loss of sleep and of appetite produced by pain. We have seen many patients in whose cases a malignant lesion has been suspected because of the loss of weight.

#### EXAMINATION OF THE PATIENT

Although the general physical examination of the majority of the patients suffering from protruded disk is found to be satisfactory for the patient of his particular age this part of the investigation should not be neglected if the risk of treatment is to be kept to a minimum. There is no reason of course, why the patient cannot have other local or general diseases which might influence the treatment and even the diagnosis. If tuberculosis, bronchiectasis, diabetes, hyperthyroidism, hypertension, prostatic pregnancy, obesity, Paget's disease, spondylitis, spondylolisthesis or any other disease is present, the fact should be noted and considered in the general summation of the problem and proper emphasis should be placed where it is indicated. There is no use in operating and removing a protruded intervertebral disk unless there is sufficient reason to believe that the patient will be materially benefited thereby and will not be subjected to an unwarranted risk.

In the course of the examination anteroposterior and lateral roentgenograms of the spinal column should be taken. In some cases oblique views also are necessary. Spondyliti-

tuberculosis of the spinal column, and metastatic and primary neoplasms of the spinal column should be excluded

A competent orthopedic examination is essential and, if the opinion of a well trained orthopedist is sought, he may be able to recognize some osteopathy that has escaped detection. It is the practice in the clinic to have any patient in whose case there is suspicion of a protruded intervertebral disk examined by an orthopedic consultant before the patient is sent for a lumbar puncture

The neurologic examination may in itself reveal enough positive findings to warrant the diagnosis of an intraspinal space-taking lesion, however, an accurate interpretation of those findings is dependent on a knowledge of the patient's history, the roentgenologic findings and those of the orthopedist. Without a knowledge of the fact that the patient's symptoms have been intermittent or that he suffered from backache for many years before a particular strain, which was followed almost immediately by paraplegia, a diagnosis of intraspinal neoplasm rather than of protruded intervertebral disk would be made. In many cases the neurologic findings are few and in some cases they are absent (Table I)

These statistics are founded principally on the results of our studies of the records of protrusions of lumbar disks, since protrusions of lumbar disks constitute by far the vast majority of the protrusions encountered and because if their origin, mode of involvement of nerve roots, type of symptoms produced, and so forth, are thoroughly understood, those protrusions occurring in other parts of the spinal canal can be recognized. The protrusions occurring in the cervical and thoracic portions of the spinal column present the symptoms and signs of an intraspinal neoplasm, more often than protrusions in the lumbar portion and unless there is a definite history of trauma preceding the onset of symptoms and unless the symptoms have been intermittent, it may be impossible to make the diagnosis until the lesion is uncovered at the operating table

In all cases in which protrusion of an intervertebral disk is suspected, lumbar puncture should be performed and a careful analysis of

TABLE I —NEUROLOGIC SIGNS IN 285 CASES OF PROTRUDED LUMBAR INTERVERTEBRAL DISKS

	Cases	Per cent
Positive Lasègue sign	231	81
Sciatic tenderness	172	60
Achilles reflex diminished or absent	171	60
Hamstring reflex diminished or absent.	51	18
Muscular paresis	63	22
Sensory loss	62	22
Examination objectively negative	17	6
Examination objectively negative except for positive Lasègue sign or sciatic tenderness	42	15

a specimen of cerebrospinal fluid should be made. The most important information obtained is that relating to the presence or absence of a subarachnoid block and the amount of total protein contained in the fluid. It is rare to find a subarachnoid block associated with lumbar protrusions unless there is paraplegia, and it is infrequent that one finds a total protein content of more than 80 milligrams per 100 cubic centimeters of cerebrospinal fluid. If there is a subarachnoid block, a yellow fluid or a total protein content of more than 200 milligrams per 100 cubic centimeters, the presence of an intraspinal neoplasm should be suspected. We have encountered many unsuspected neoplasms among our cases in which protrusion of an intervertebral disk was suspected

#### INCIDENCE OF PROTRUDED INTERVERTEBRAL DISK

It is difficult or impossible to estimate the frequency of protrusion of intervertebral disks. In private practice this condition must account for only a very small percentage of the cases in which the physician is called on to treat backache and sciatic pain. The good results that most physicians obtain by conservative therapeutic methods would seem to confirm this. On the other hand, every physician who is called on to treat such conditions must occasionally encounter a pain that is intractable. It is from this latter group of intractable backaches and sciatic pains that the cases in which protrusion of a disk is suspected come

The practice at the Mayo Clinic cannot be compared readily with that of the private physician, orthopedist, neurologist, or neurosurgeon. Patients who come to the clinic or are

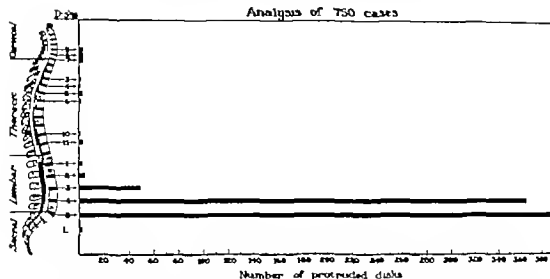


Fig. 1. Frequency of protrusion of different intervertebral disks into the spinal canal. On the left, coronal section of the normal spinal column and, on the right, the interspaces and the numbers of protruded intervertebral

disks which occurred in those interspaces. *L6* refers to the number of protruded intervertebral disks which were found in those cases in which there were 6 lumbar vertebrae.

referred here because of a complaint of back ache or sciatic pain or both are usually those who have failed to obtain permanent relief by ordinary methods at home. The condition is most likely to be of long standing and since the syndrome of protruded intervertebral disk has become fairly well known many patients are referred for operation after the diagnosis of protrusion of a disk already has been made by the referring physician. These factors tend to make our statistics seem out of line with those of others.

According to Dr. Henderson, chief of the Section on Orthopedic Diagnosis, he and his associates in that section were called on in 1940, to see approximately 5,500 patients who had backache as a symptom (including backache, sciatic pain, root pain, spondylitis, spondylosis, sacroiliac disease, symptoms causing suspicion of a protruded disk, fibrositis, and so forth). It is from this group that our cases of protruded disk come. Approximately 13 per cent of the 5,500 patients were found to have one or more protruded disks as the cause of their complaints.

The incidence of protrusion of different disks into the spinal canal from their normal positions

at the various levels of the vertebral column is shown in Figure 1.

#### DIAGNOSIS OF PROTRUDED INTERVERTEBRAL DISK

The diagnosis of a protruded intervertebral disk in the lumbar region of the spinal canal should not cause any difficulty when the patient presents the so called classic picture and gives the typical history. If a patient walks into the examining room with a listing of the body and appears to be suffering from pain, one is likely to find on examination (which should be made with the patient stripped) that there is a loss of the lumbar lordosis, that is, a flattening of the lower part of the back, marked spasm of the erector spinae muscles and limitation of the spinal movements. If perextension is likely to be not only limited but extremely painful. If the patient stands without a list he is prone to list on forward bending of the trunk on the pelvis with the knees stiff (straight). There usually is tenderness over the spinous processes of the lower lumbar vertebrae. When the patient is examined while in the dorsal recumbent position, straight leg raising is limited and painful

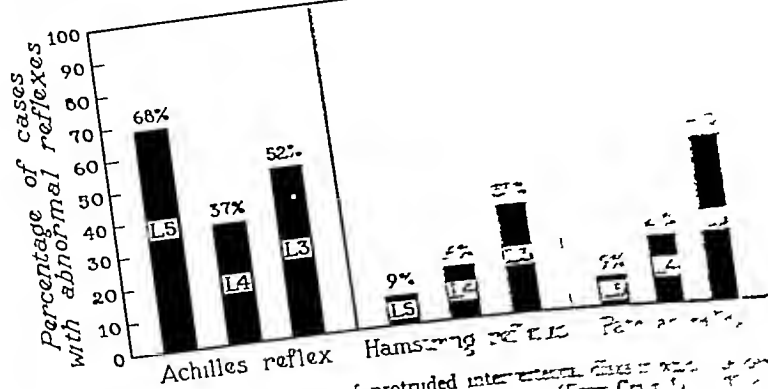


Fig 2 Percentage of cases of protruded intervertebral discs with abnormal tendon reflexes in the lower extremities are abnormal (From Walsh, M N J Bone Surg, 1941, 23 417-43-)

on the side of the sciatic pain and in severe cases the straight leg raising test may give bilaterally positive results even though the patient has complained of pain in the course of only one sciatic nerve. Kernig's sign, likewise, will be positive and bending of the head forward on the chest will in some cases aggravate the low back or sciatic pain or both. The course of the sciatic nerve from the sciatic notch to the terminations of its terminal branches should be palpated to elicit the tenderness, which in some cases is extreme. Of course, while palpating, the examiner should seek to exclude a primary tumor of a nerve also. We have encountered one primary tumor of the sciatic nerve which masqueraded as a protruded disk.

The Achilles reflex on the side of the sciatic pain is usually diminished or absent. This is more likely to be true if the protrusion is lumbosacral than if it is at a higher level, but an absent Achilles reflex by no means excludes a protrusion at a higher level (Figs 2 and 3). There may be slight disturbance of sensation over the outer and dorsal aspects of the foot, but extensive sensory loss is rare unless there is a very large lesion and then there are likely to be both motor and sensory loss and an associated disturbance of the anal and vesical sphincters.

The history of the patient presenting the foregoing findings in the typical case would be something like this. He or she is accustomed to heavy work which entails the placing of un-

usual stress or strain particularly in the lower extremities. An onset of bilateral sciatic pain is associated immediately with extension of pain at the sciatic nerve, rarely, but intermittently and only by rest, locally applied heat, massage and other usual measures. The pain has been aggravated by sneezing or straining, which has disturbed the patient's weight resulted due to the weight of the body. With that history, the diagnosis of a protrusion of a lumbar intervertebral disk would be the diagnosis until proven otherwise. An unsuspected neoplasm of the spine could duplicate the picture.

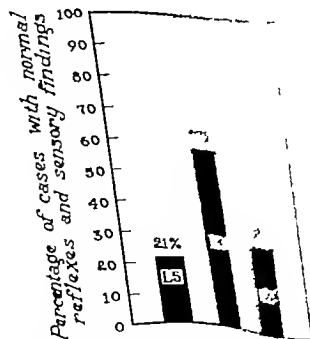


Fig 3 Percentage of cases of protruded intervertebral discs in which the deep tendon reflexes and sensory findings in the lower extremities are normal.

bility of such a neoplasm must always be considered in the differential diagnosis along with the other conditions enumerated under incidence of protruded disks.

#### FINDINGS ON EXAMINATION OF SPINAL FLUID IN CASES OF PROTRUDED DISK

When the protrusion is large enough to produce gross neurologic findings as the result of extensive pressure on the spinal cord or cauda equina, the findings on lumbar puncture are likely to resemble those obtained in the presence of intraspinal neoplasms, namely disturbance of the normal hydrodynamic relations with a tendency to subarachnoid block and a high concentration of total protein. However, since most of the protrusions encountered are relatively small and usually irritate and compress only one nerve root, the vast majority of the patients do not have a disturbance of the hydrodynamic relations of the cerebrospinal fluid and the total protein content of the fluid is usually not markedly elevated. In approximately two-thirds of the cases the concentration of total protein in the cerebrospinal fluid is 40 milligrams per 100 cubic centimeters or more, whereas in fully a third the concentration of total protein is less than 40 milligrams per 100 cubic centimeters.

In the presence of low back and sciatic pain without a sensory level, if the fluid is yellow, if there is a high total protein content, or if there is a subarachnoid block, a neoplasm should be suspected. One of the commonest under these circumstances is an ependymoma which has arisen from the filum terminale.

#### CONTRAST MEDIA IN THE DIAGNOSIS AND LOCALIZATION OF PROTRUDED DISKS

Our early knowledge concerning the diagnosis and localization of protrusions of disks was obtained principally from the roentgenoscopic examination of the spinal canal into which radiopaque oil (Ipiodol) had been injected. As our experience has increased we have reached a point where we feel that our clinical diagnosis is just as accurate as the roentgenoscopic diagnosis obtained by the aid of radiopaque oil and more accurate than that obtained by the aid of air which we now use almost routinely prior to operation.

Because of the slow absorbability of radiopaque oil and the medicolegal complications which might follow its employment, we have all but abandoned its use in cases of protruded disk. It is still used when indicated for the localization of intraspinal neoplasms and in selected cases of protruded disk.

Although air is absorbed rapidly and does not leave any telltale stigmas to be recorded on subsequent roentgen examination its accuracy according to Camp is far less than that obtained with radiopaque oil.

One should not expect the roentgenologist to be able to diagnose and localize protruded disks in a very high percentage of cases with airoxygen. Spunograms (air "myelograms") when considered as only a part of the examination and evaluated along with the history and other findings, are of definite value but alone they are often valueless. One of the most important uses for air in this group of cases is to exclude an unsuspected intraspinal neoplasm and the presence of multiple lesions. Air in our experience is practically valueless in thoracic and cervical intraspinal lesions. Its use in our hands is restricted almost entirely to those cases in which a lesion in the lumbar portion of the spinal canal is suspected.

The technique we employ in dealing with patients suspected of having a protrusion of a lumbar disk is as follows. The patient is given a sedative usually one of the barbiturates, about 30 to 45 minutes before being called to the x-ray room. He is placed on his right side on the tilting x-ray table while the table is horizontal. After the back has been cleansed with ether and alcohol, two coats of tincture of mercuriolate are applied to the skin of the entire lumbar region. With the patient under local (1 per cent solution of procaine hydrochloride) anesthesia a lumbar puncture needle is introduced into the subarachnoid space through the second lumbar interspace that is, the space between the spinous processes of the second and third lumbar vertebrae. When fluid is obtained a manometer (Ayer type) is connected and routinely the Queckenstedt test is performed. As has been stated, we do not expect to find a "block," for we are purposely puncturing above the site of the suspected lesion. After the pressures have been

recorded, 10 to 15 cubic centimeters of fluid is collected and placed in a sterile bottle to be sent to the cerebrospinal fluid laboratory for the following tests — Wassermann, globulin, cell count, total protein, and colloidal gold curve. Then the patient's head is lowered 40 degrees away from the horizontal by elevating the foot of the tilting x-ray table. All of the fluid in the lumbar portion of the spinal canal is then replaced with air or oxygen. Usually about 40 cubic centimeters of fluid, in addition to what was collected for a specimen, is obtained. We usually inject an additional 10 to 20 cubic centimeters of air but this should not be under undue pressure. Approximately 50 to 60 cubic centimeters of air is necessary to get a satisfactory filling of the lumbar subarachnoid space.

While the head is still low and after the lumbar puncture needle has been removed and the puncture wound has been sealed with sterile cotton soaked in collodion, stereoscopic lateral roentgenograms are made. Then the patient is turned over on his back and stereoscopic anteroposterior roentgenograms are made. The patient is then returned to his bed and is advised to keep his head low for 24 hours, during which time he receives inhalations of oxygen by mask in order to promote more rapid absorption of the air.

The interpretation of spinograms is very difficult and there are many pitfalls. One looks, however, not only in the anteroposterior but also in the lateral views for defects, due to a lateral or posterior deviation or both of the air shadow at one or more intervertebral spaces. As has been stated, the finding of a complete block is rare.

#### PREOPERATIVE PREPARATION

When it has been decided that a protruded intervertebral disk is present and operation is indicated, the latter should be carried out without delay. We have found from experience that it is better to delay the taking of roentgenograms of the spinal canal into which a contrast medium has been injected until the patient is ready to proceed with operation in case it is indicated. Even though air is used as a contrast medium, it is fairly common for the patients to experience considerable exacer-

bation of their low back and sciatic pain and in addition to complain of headache and of pain between the shoulders and around the chest after the introduction of air into the subarachnoid space. Likewise, the patient may be troubled with nausea and vomiting. Since the operative removal of a protruded intervertebral disk requires a relatively short period of hospitalization and since the reaction after the taking of spinograms may persist for several days, the economic factor alone is worth considering and the patient should be ready to go ahead with the operation in case it is necessary. Even in spite of a reaction after the taking of spinograms, we rarely find it needful to postpone the necessary operation. Usually the spinograms are taken in the morning and the operation is carried out the next morning, after the spinograms have been studied and interpreted in conjunction with the history and physical and neurologic findings and the results of the examination of the cerebrospinal fluid.

Elaborate preparation for operation is not required. The patient has had cleansing enemas preliminary to the taking of the spinogram and further attention to the bowel is not necessary. The patient is given a light supper on the evening prior to operation but breakfast is withheld on the morning of operation.

Commonly, if the patient is to have the usual anesthetic agent, namely, drop ether,  $\frac{1}{6}$  grain (0.01 gm) of morphine and  $\frac{1}{150}$  grain (0.00043 gm) of atropine are injected hypodermically approximately 30 minutes before administration of the anesthetic agent is started. If the operation is to be performed with the patient under spinal analgesia,  $\frac{1}{2}$  to 3 grains (0.1 to 0.2 gm) of pentobarbital sodium (nembutal) is administered 45 minutes to 1 hour before the spinal analgesic agent is to be administered, and  $\frac{1}{6}$  or  $\frac{1}{4}$  grain (0.01 or 0.016 gm) of morphine, depending on the patient's age and weight, is given 30 minutes prior to the introduction of the spinal puncture needle. The same preoperative medication plus atropine is used if the patient is to be operated on under the influence of pentothal sodium which is intravenously administered.



## CHOICE OF ANESTHETIC AGENT

As was stated previously the anesthetic agent most commonly employed is drop ether. The patient is anesthetized by a combination of nitrous oxide and oxygen, and then drop ether is substituted. Some of the surgeons at the clinic prefer to have a McGill intratracheal tube introduced after the patient is asleep and then drop ether is administered over the outer end of the intratracheal tube. If the patient has recovered recently from an infection of the upper part of the respiratory tract or there is any question regarding the advisability of using an inhalation anesthetic agent such as ether the operation may be performed while he is under spinal analgesia or under the influence of intravenously administered pentothal sodium. The latter anesthetic agent is particularly useful for persons who are unduly nervous for those who have severe hypertension and for those who have asthma or hay fever.

## OPERATION

After the patient has been anesthetized he is placed on the operating table in the face down or prone position except in cervical operations, in which we prefer to operate with the patient in the upright position such as is used for operations in the posterior fossa of the skull. The skin about the region of the operation should be shaved carefully and cleaned thoroughly with ether and alcohol before the cutaneous antiseptic agent is applied. The cutaneous antiseptic agent which we use is tincture of merthiolate. Two liberal coats of the antiseptic agent are applied. Double towels are then placed to either side of the spinous processes and about 1 3/8 inches (4 cm.) lateral to the midline. Double towels are then placed above and below crossing the towels previously placed and only far enough apart to leave uncovered an area of skin sufficient for adequate exposure. Ordinarily this interval should not exceed a distance corresponding to three spinous processes.

The incision is midline and is carried down to the tips of the spinous processes. Ordinarily in case of unilateral symptoms and signs it is necessary to reflect the muscles only on one side. If the symptoms and signs are bilateral or if a midline protrusion of the disk

is suspected the muscles should be reflected bilaterally. The muscles are reflected from the spinous processes and laminae by means of a sharp chisel and the reflections should be subperiosteal. In this way hemorrhage from the muscles is reduced to a minimum. When the muscles have been reflected, gauze sponges are packed between the bone and the muscle while the previously caught bleeding vessels in the skin and subcutaneous tissue are controlled by electrocoagulation applied to the hemostatic forceps. Care should be taken in electrocoagulating these vessels lest too much heat be applied with the resultant sloughing of the cutaneous margins. The gauze packed between the bone and the muscle serves two distinct purposes. It further tends to control whatever slight bleeding may be occurring, either in the bone or in the muscles, and it tends to iron out the muscles and provide better exposure. If the muscles are reflected over a distance sufficient to permit the introduction and use of the large laminectomy self-retaining retractors, these are inserted deeply into the wound and the muscles are spread away from the bone. If the incision is short like that now ordinarily employed when the protruded disk is to be removed without the sacrifice of any bone the medium-sized self-retaining retractor is used to spread the skin and the gauze sponges are left packed in the wound until the wound towels have been applied.

If the procedure usually employed by one of us (Love 8) is used the ligamentum flavum at the interspace where the protruded disk is located is resected by the aid of a ground-down Adson curved periosteal elevator. The ligament is cut away from the upper margin of the lamina of the vertebra below and then the periosteal elevator is inserted under the lower margin of the lamina of the vertebra above. The ligament is dissected free above and below down to the dura mater seized with a Kocher forceps, cut away from the interspinous ligament with a pair of scissors, and then turned laterally and resected with scissors as far laterally as possible. While carrying out this procedure one usually notices that the ligament is thicker, less yellow and more whitish or grayish and much more fibrous than is the normal ligamentum flavum. Underneath

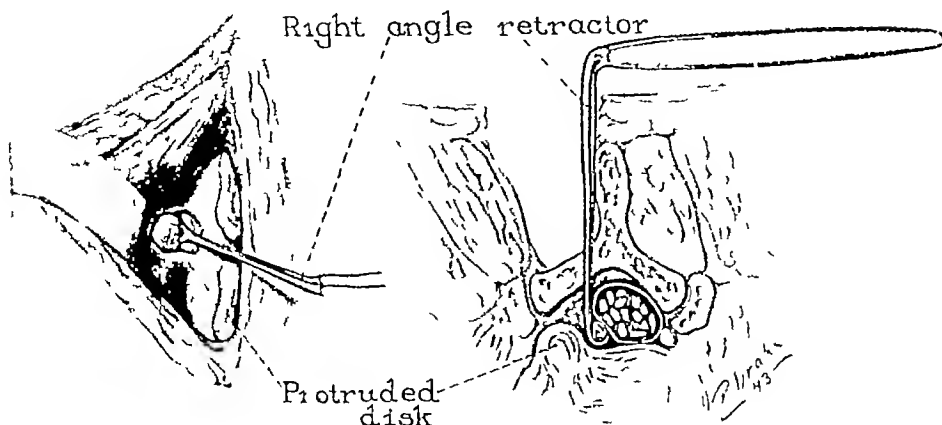


Fig 4 Extent of the operative procedure which is required in the average case of protruded inter vertebral disk. A special right angled retractor is in place, retracting the edematous compressed nerve root and exposing the protruded disk which is to be removed with a modification of the Gruenwald forceps

the ligament one encounters usually either a large, tortuous extradural vessel or an enlarged, hyperirritable nerve root. Underneath the nerve root the protruded disk is palpated. If the protrusion is the typical unilateral extrusion the nerve root is retracted toward the midline with the straight or right-angled (Love, 7) nerve root retractor (Fig 4). At this point the surgeon will find in many cases that the protrusion is lying free and can be lifted out with the Gruenwald ethmoid forceps, or he may find that the protrusion is still covered by the posterior longitudinal ligament. Often this ligament is so thin and yielding that it is penetrated easily with the use of a forceps. Sometimes the ligament is dense and incision with a sharp instrument, such as the ureteral knife, is required before the protrusion can be removed. The protruded fragments of cartilage are then removed with the Gruenwald forceps. Care should be exercised lest loose fragments within the center of the disk be overlooked. In the majority of cases, the protruded portion of the disk can be removed in this fashion without opening the dura mater and without the sacrifice of any bone.

If there is unusual narrowing of the interlaminar space, if the protruded fragment of cartilage has wandered away from its usual position opposite the interspace or if the pro-

trusion is unusually large or is in the midline position, it may be necessary to do some type of laminectomy. Classic laminectomy, consisting of the removal of one or more spinous processes and two or more laminae, may be required. In this operation, as in all operations, adequate exposure is essential. The articular facets should always be preserved. It may be sufficient to shear off a portion of the spinous processes of two adjoining vertebrae with or without the removal of the margins of the laminae of the adjoining vertebrae. Hemilaminectomy without the sacrifice of a spinous process may afford ample exposure. At times one need only remove a few bits of bone from the lower margin of the lamina of the vertebra above the interspace or from the upper margin of the lamina of the vertebra below the interspace at which the protrusion has occurred.

Rarely, when an unusually large midline protrusion, because of its size, has produced paraplegia and considerable edema of the cauda equina, it may be necessary to approach the protrusion transdurally. In such cases it is essential to perform laminectomy and to incise the dura mater, first posteriorly, and then anteriorly over the dome of the protrusion between the strands of the cauda equina. Under such circumstances, the cauda equina should be protected carefully with strips of cottonoid

soaked in physiologic saline solution and manipulation of it should be kept at a minimum. Ordinarily it is unnecessary to suture the anterior incision in the dura mater unless one has had to make an unusually long incision or sharp bleeding has been encountered anterior to the dura mater. The posterior incision of the dura mater should always be closed to prevent a cerebrospinal fluid leak and in order to maintain the hydrodynamic effect of the cerebrospinal fluid and thus minimize the danger of postoperative hemorrhage.

Previously one of us (Love) and Camp (9) stated that drainage of the wound usually is necessary. As our experience with this lesion has increased we find that it is rarely necessary now to insert a drain in the wound. There are two principal reasons why this is so: (1) The removal of bone has been reduced to a minimum. (2) The dura mater rarely is opened. Since the dura mater is not opened the normal hydrodynamic effect of the cerebrospinal fluid is maintained and even though bleeding is sharp during the retraction of the nerve root for the removal of the protruded portion of the disk, as soon as the retraction is stopped the thin walled extradural veins cease to bleed. If bleeding should continue the application, over the site of bleeding, of a small pledget of muscle which has been pounded thoroughly to liberate the tissue juices will suffice to control hemorrhage. If in spite of this, bleeding should continue, a strip of plain gauze 1 inch (2.5 cm.) wide should be plicated over the site of the bleeding and then suction applied to a strip of cottonoid placed on top of the plicated gauze. As soon as the bleeding has been controlled, the cottonoid should be removed before the wound is closed. The strip of gauze should be removed at the end of 48 to 72 hours. If the strip of gauze is packed against the nerve root or anterior to the common dural sac, pentothal sodium should be administered intravenously and the patient should be asleep before it is removed. Otherwise excruciating pain will result when traction is applied to the gauze.

Whether or not the wound is drained, it should be closed in layers. The muscles are approximated with interrupted No. 1 chromic catgut sutures, as is also the fascia. The sub-

cutaneous tissues should be anchored to the fascia with No. 0 chromic catgut in order to obliterate the dead space and the skin should be approximated with a continuous stitch of silk. Either sponges of dry gauze or sponges soaked in alcohol are applied to the wound and then a large cotton pad dressing is applied over the gauze and fastened securely with adhesive tape. The dressing is not sealed in with the adhesive tape as it is considered advisable to permit air to get to the wound and surrounding skin. In this way the likelihood of maceration of the skin, particularly if there is drainage, is minimized.

#### POSTOPERATIVE CARE

Patients who have had an operation on the back for the removal of a protruded intervertebral disk are placed on their sides in a bed that has boards under the mattress and they are encouraged to turn themselves as soon as they feel like it and as often as they desire although they are advised to refrain from lying on their backs until the wound is well healed. The reason for avoiding the supine position is the feeling that the other positions are more comfortable and the wound will heal better if pressure is not permitted. During the first 24 to 48 hours an order is left for the patient to have  $\frac{1}{4}$  grain (0.01 gm.) of morphine every 4th hour if it is needed. Many of the patients do not require the morphine. Patients are allowed to take fluids as soon as they have the desire and by the 3d or 3d day they can be on a full hospital diet. If the patient is unable to void, women are catheterized every 8th hour beginning the morning after the day of operation. At this time men who have had one of the less extensive operations are permitted to stand beside the bed and use the urinal and if they are unsuccessful they too are catheterized. It is unusual for a patient to need catheterization after the 3d or 3d day. The bowels are opened on the morning of the 3d day with the assistance of an enema of soapuds. The patients who have had the less extensive operations are permitted to dangle their feet over the side of the bed on the 5th postoperative day to sit in a chair on

<sup>9</sup>More recently the patients sit up the 5th day, have coffee at that time and go to the bathroom the next morning.

the 6th and to begin walking on the 7th. The sutures in the skin are removed on the 9th or 10th day after operation.

Most of the patients are out of the hospital by the 12th day after operation. After leaving the hospital, the patients report to the office for postoperative examination and advice before dismissal from our care, which usually takes place about the 14th or 15th day after operation. All patients are advised to spend 3 months convalescing before returning to their former activities. Those in the heavy types of work need a period of reconditioning or training before assuming full duties.

#### COMPLICATIONS

Although patients suffering from protruded intervertebral disks come to the physician seeking relief principally from pain, which may vary tremendously in intensity from a minor annoyance to that which is so severe as to result in complete disability, a protruded disk may give rise to complications which threaten the life of the patient. Some patients, because of the severity of the pain, lose their appetites and are unable to sleep. As a result of these two factors the patient may lose considerable weight and become debilitated, or he may become addicted to the use of narcotic agents. If the protruded portion of the disk is not removed and pressure on the spinal cord or one or more nerve roots is allowed to persist, irreparable damage to the nervous system may occur. Marked atrophy of the muscles of an extremity may take place, drop foot may develop, or if the protrusion is large, paraplegia, in the case of a lumbar lesion, or even quadriplegia, in the case of the less common cervical lesions, with loss of control of bowel and bladder, may occur. As a result of the disturbance of function of the bowel and of the urinary tract, severe renal damage, uremia, and death may ensue.

Probably under the head of complications one should include the discussion of other conditions which might be present and might influence the diagnosis, the treatment, and the result of the treatment obtained in cases of protruded intervertebral disk. Although we have been taught, and ordinarily try, to make one diagnosis explain the symptoms of a given

patient, it may be necessary in some cases to make multiple diagnoses. For instance, it is fairly common for a patient who has a protruded disk to have definite evidence also of arthritis of the spine. Then, too, occasionally one sees a patient suffering from diabetes mellitus who has the symptoms and signs of a protruded intervertebral disk. MacKay has reported from the service of one of us (Love) the association of protruded intervertebral disk and Paget's disease of the pelvic bones. In the presence of one of these complications one cannot anticipate complete relief of all the patient's symptoms even though one operates and removes a protruded intervertebral disk. However, provided the patient and the surgeon discuss the situation and the patient understands that there are two or more factors which may be playing a part in the production of the symptoms from which he seeks relief, it is our feeling that, if a protruded intervertebral disk is present and is contributing to the production or aggravation of the patient's symptoms, in view of the small risk of the operative removal of such a protruded disk operative removal should be advised and carried out.

#### FUSION

The advisability of performing a bone graft at the time of removal of a protruded intervertebral disk is debatable. There are those who believe that in every case it would be advisable to insert a bone graft after the removal of a protruded intervertebral disk. At the other extreme are those who believe that a bone graft is rarely, if ever, necessary. Obviously, the truth lies somewhere between these two extremes of opinion. It is our feeling that in some cases a bone graft not only is indicated but is necessary if the patient is to obtain the best result from his treatment. In cases of frank spondylolisthesis in which there is an associated protrusion of an intervertebral disk and particularly if the lesion is at the lumbosacral interspace, we feel that a bone graft should be performed. For patients who narrate a long history of static backache before the onset of sciatic pain and whose roentgenograms reveal definite evidence of disease of the vertebrae, fusion will, we believe, give the best result. Narrowing of an interspace

*per se* is not a sufficient indication for fusion. Neither is the presence of spina bifida occulta.

If a fusion operation is to be carried out, we at the clinic work with the consultants in the orthopedic section at the time of the operation. While the neurosurgeon is removing the protruded intervertebral disk, the orthopedic surgeon removes a massive bone graft from the flat internal surface of the tibia. When the neurosurgeon has completed his part of the operation the orthopedic surgeon takes over and inserts the bone graft to accomplish the desired fusion. Although, when two surgical teams operate together the actual time required for the operation is not increased appreciably the period of hospitalization and time of convalescence are prolonged considerably. This is a factor which we feel should be considered carefully before one advises such a procedure. For instance even though the indications are present for a combined operation if the patient has reached the age of 55 years or more prolonged hospitalization may increase the risk. A patient who has reached this age may be able to avoid the things which ordinarily produce backache and to get along quite satisfactorily without the fusion being performed.

#### RESULTS

The results of the operative removal of protruded intervertebral disks have in our hands been excellent. The mortality rate has been less than 0.25 per cent. Complete relief of the symptoms for which the operation is performed should occur in 80 per cent of cases. The patients who have not sustained irreparable damage to the spinal cord or nerve roots should obtain relief without any sequelae. In cases in which considerable atrophy of the muscles of an extremity has developed or in which there is extensive and severe sensory loss or drop foot the patients may be relieved of the pain of the nerve root for which the operation is performed but the gross neurologic changes may persist. The results in operations for protrusions in the lumbar region of the spinal column are consistently better than those obtained in operations for protrusions in the cervical and thoracic portions of the spinal column. There has been an incidence of approximately 2 per cent of recur-

rence of the protruded disk in the cases in which protrusion was in the lumbar region. The recurrence in practically every case has been at the site of the original protrusion and the operative treatment consists in removal of the recurrent protruded fragment of cartilage which is compressing the nerve root. A small group of patients although relieved of their sciatic pain will continue to complain of aches and pains in the lower part of the lumbar region which may vary in intensity from a mild nuisance to incapacity for the heavier types of work.

In order to achieve what we consider to be satisfactory results in the treatment of intractable root pain due to protruded intervertebral disks every case in which a protrusion of an intervertebral disk is suspected is evaluated very carefully by our staff and all such patients are seen in neurosurgical consultation before a diagnostic lumbar puncture is performed. In this way many borderline patients, many who can carry on quite satisfactorily with conservative orthopedic measures, and many who have symptoms and signs suggesting but not definitely indicating protruded intervertebral disks, are spared the discomfort, time and expense of lumbar puncture and visualization of the lumbar portion of the spinal canal. The conservative orthopedic measures which are advised by our orthopedic colleagues consist of the wearing of a so called sacroiliac belt by patients suffering from a low back or sciatic pain or both. In addition physical therapy in the form of heat and massage is prescribed if the patient is ambulatory. If the patient is suffering so that he is unable to be up and around rest in bed with boards under the mattress bilateral Buck extension and a lumbar sling are prescribed. In addition he may receive diathermy treatments and physical therapy. Many patients suffering from protruded disks will tolerate such treatment poorly and neurologic signs may even develop which will give unmistakable evidence of an intraspinal lesion and thus give clear indication for operative intervention. Many borderline patients when first seen are advised to follow conservative nonoperative treatment for 3 to 6 months before considering intra spinal surgical treatment.

Since the operation for the removal of a protruded intervertebral disk is a highly technical surgical procedure and one which not only can produce a brilliant result but also can result, if improperly conceived and carried out, in complications which are more disastrous than the original condition for which the procedure was designed, it is essential that as much as possible be known about the nature and location of the intraspinal lesion before the operation is undertaken. A carefully conceived and well executed removal of the offending cartilage should result in the alleviation of the patient's pain and disability with a minimal risk to life and limb. The mortality rate at the clinic has been less than 0.25 per cent, as previously stated.

The results of operation on patients who are receiving compensation or insurance and on those who have litigation pending have not been so good as the results for the patients who are interested only in getting well. Thus, it would seem, is natural and easily understood. On the other hand, it does not mean that patients in whose case there is a medico-

legal angle do not obtain relief or do not return to their former occupations, nor is it intended as justification for withholding necessary surgical treatment from patients who are found to fall into this group. However, one must realize that medicolegal cases do present a real problem and that it is necessary not only to find the cause of the patient's disability and to remove it but also to convince him that he has been relieved and that he is able to return to his work.

## REFERENCES

- 1 ADSON, A. W. *Northwest M.*, 1925, 24, 309-317
- 2 CAMP, J. D. *Minnesota M.*, 1940, 23, 688-692
- 3 DANDY, W. E. *Arch Surg.*, 1929, 19, 660-672
- 4 DEUCHER, W. G., and LOVE, J. G. (Abstr.) *Arch Path.*, 1939, 27, 201-211
- 5 GOLDTHWAIT, J. E. *Boston M. & S. J.*, 1911, 164, 365-372
- 6 LOVE, J. G. *Proc Mayo Clin.*, 1936, 11, 529-536
- 7 *Ibid.*, 1937, 12, 393-394
- 8 *Ibid.*, 1939, 14, 800
- 9 LOVE, J. G., and CAMP, J. D. *J. Bone Surg.*, 1937, 19, 776-804
- 10 MACKAY, A. R. *Proc Mayo Clin.*, 1941, 16, 138-140
- 11 MYNTER, W. J., and BARR, J. S. *N. England J. M.*, 1934, 211, 210-215
- 12 STOOKE, BYRON. *Arch. Neur. Psychiat.*, 1928, 20, 275-291

# A COAGULUM CONTACT METHOD OF SKIN GRAFTING AS APPLIED TO HUMAN GRAFTS

NACHTELD F. SANDO, M.D., Philadelphia, Pennsylvania

**D**URING the last 2 years a new method of skin grafting was developed and the preliminary animal experiments were reported (1). While further simplifications have since been made in the technique (2) the method as first propounded has been applied to human grafts and is the basis of this report.

## METHOD

Into a 10 cubic centimeter syringe containing 1 milligram of heparin dissolved in 1.0 cubic centimeter of Tyrode's solution (a buffered salt solution) 5 cubic centimeters of the patient's blood are drawn. The blood is centrifuged and the plasma transferred to a small 5 cubic centimeter test tube all procedures being done under sterile conditions. One and a half cubic centimeters of Tyrode's solution are added to the remaining red cells and buffy coat (white cells) or to the buffy coat alone if it is convenient to separate it from the erythrocytes. This cell mixture is agitated vigorously and to assure thorough disintegration of the cells a few sterile glass beads are added. If the buffy coat has not been separated from the red cells the mixture must be centrifuged and the supernatant fluid removed to another sterile tube. If the buffy coat alone is used centrifugation is not necessary as the cellular fragments do not interfere with the grafting. This fluid whether prepared from the buffy coat or from the erythrocytes plus the buffy coat will be referred to as cell extract.

In preparation for the actual grafting the recipient area is washed with warm sterile saline and dried with gauze. The donor area is sterilized by whatever method the operator prefers. Thin split grafts to full thickness grafts can be used the size of the graft being

of any desired dimensions. The graft is turned upside down on a sterile piece of gauze without washing in saline as such washing tends to remove tissue extracts which aid in producing the required coagulum. With a camel's hair brush the under side of the graft is moistened lightly with the cell extract. With another brush the plasma is painted on the recipient area. The graft is quickly fitted into the recipient area. The edges are carefully adjusted and slight pressure with the forceps is applied to the graft to assure good contact. It adheres within a few minutes. A single strip of boric acid gauze is lightly placed over the graft to protect it from infection and drying. No other dressings are applied, no stitches are needed. If esthetic results are desired the graft is made slightly larger than the recipient area and the edges are trimmed to fit exactly. Even the edges will adhere well if there is no bleeding and bleeding rarely occurs as no stitches are required to fix the graft in place. Within 48 hours the graft becomes purplish and the circulation sufficient to take care of any serous fluids which might accumulate underneath. Sections of grafts on rats have shown that the small vessels are filled with healthy erythrocytes. In fact it is difficult after more than 48 hours to determine microscopically the exact site of union between the graft and underlying tissue.

Through the co-operation of the department of surgery of Temple University Hospital we have been able to apply numerous grafts on 10 different patients. Approximately 100 square inches of skin have been grafted of which less than 1 square inch has been lost. The varying clinical problems and the wide range in the type of grafts used have been so inclusive that they give a good idea of the scope and reliability of this new method. I am especially indebted to Dr. W. E. Burnett through whose co-operation we were first able to use the method clinically and to whom the first 5

From the Department of Pathology and Surgery, Temple University School of Medicine and Hospital, Philadelphia.

One milligram heparin (Heparin Warriner and Dunning) prevents the coagulation of 7 c.c. cit. blood for 1 hour.

cases of this series belong. The cases in this series have been reported chronologically and the surgeon in charge in each instance indicated. I should like to take this opportunity to express to them my appreciation for their co-operation and for their permission to publish the brief abstracts of their patients' histories.

#### CASE HISTORIES

**Case 1** A white boy, aged 5 years, had the tip of his nose bitten off by a dog on September 14, 1942. He was treated with sulfathiazole ointment (dog showed no evidence of hydrophobia). A thick split skin graft was applied on September 15, 1942. The graft turned deep purple about 48 hours later. The patient went home without a dressing 3 days later. For end results see Figure 1. (Dr W E Burnett's case)

**Case 2** A colored mentally backward child, aged 19 months, had the left arm burned 6 months previously with resultant disfigurement and scarring, over left wrist, left forearm, and elbow, causing much deformity. The scar was removed and a thin split graft was applied over left wrist and left elbow. The scar of left forearm was removed and the wound was closed with wire sutures. Three days later, viridans streptococci infection developed in forearm and at edges of graft. The graft was well vascularized and there was no loss of skin notwithstanding infection. Sulfathiazole ointment was applied. (Dr W E Burnett's case)

**Case 3** White male, aged 28 years, received a crushed index and middle finger on October 11, 1942. Débridement was carried out and a medium split skin graft was applied on index finger by means of the new method. Stitches and pressure dressings were applied on middle finger. Patient traumatized index finger during the night with much resultant bleeding. Neither graft took and viridans streptococci were isolated from underneath the graft. The underlying tissue was craggy and not firm. (Dr W E Burnett's case)

**Case 4** White female, aged 49 years, was treated with x-ray elsewhere for hypertrichosis of skin. Patient developed epithelioma. This was removed and left to heal completely. The scar was then removed and a full thickness graft was applied immediately. The underlying tissue was fibrous. There were several vessels which bled freely and were tied with silk sutures. Vascularization was established within 48 hours (Figs 2 and 3). (Dr W E Burnett's case)

**Case 5** White male, aged 45 years, had his left thumb partially crushed. Amputation was advised at another hospital and the tip of the phalanx was amputated. Débridement to the bone was carried out on the medial side February 9, 1943. Due to infection the grafting was postponed. On February 25, 1943, there was still a mixed coliform bacillus and Staphylococcus albus infection. A thin split graft was



Fig 1 Case 1 Three weeks after grafting

applied. It became deep purple within 48 hours. Patient returned to work 2 weeks later. (Dr W E Burnett's case)

**Case 6** White female, aged 71 years, had a squamous cell carcinoma, grade III of the left thigh removed on March 1, 1943. Some Staphylococcus albus infection of the edges developed. Full thickness graft (4 mm) measuring 8.5 by 9 centimeters was removed from under the right breast where there was excessive skin. A few streaks of yellow fat were adherent to the under surface. Graft turned deep purple within 39 hours. As the graft was too large and too thick at the edges for the area it was trimmed down after 10 days and the edges were sewed down. The graft edges when trimmed down bled freely and a section was taken to determine its appearance (Figs 4 and 5). (Dr J Blady's case)

**Case 7** Colored boy, 5 years of age, was scalded with hot water on the right arm, elbow, and shoulder. He was sent to Municipal Hospital with scarlet fever. Several thin split grafts and one full thickness graft were applied on the elbow. They were deeply colored within 48 hours. During the grafting of numerous pieces 1 graft was inadvertently brushed off and dried with the clot on. It was replaced, but only a small fragment of this took. All the other 6 grafts took well. (Dr R Teehan's case)

**Case 8** Female, aged 54 years, with chronic mastoiditis was operated on and a full thickness skin graft was applied. There was much bleeding at the time of fixation but the result 3 weeks later appears to be satisfactory. (Dr M S Ersner's case)

**Case 9** Colored male, 48 years of age, burned his right leg in boiling alkali solution. On January 23, 1943, debridement was carried out. He was seen on April 15, 1943 and skin grafting over approximately 40 square inches was done on April 16, 1943. Thin and thick split skin grafts were used. Granulation tissue had been trimmed 1 week previously. Three days later suppuration occurred around the grafts and granulation tissue. Mixed hemolytic Staphylo-





Figs. 2 and 3. Case 4. Left, 45 hours after grafting; right, 5 days after grafting.



Figs. 4 and 5. Case 6. Left, 45 hours after grafting; right, 3 weeks after grafting.

coccus aureus (pathogenic strain) hemolytic streptococcus, Group A and Staphylococcus albus were isolated. This infection was kept under control by sulfathiazole spray. On April 26, 1943 the grafts were already beginning to grow out from their edges. There was no loss of tissue. More grafts were fixed in the remaining denuded areas. These were well fixed and grew as did the previous ones (Figs. 6, 7, 8, 9). Each grafting took about one-half hour (Dr. G. P. Giambalvo's case.)

Case 5. White woman aged 67 years, had an epithelioma of the scalp removed on April 1, 1943. It was left to granulate in but on April 26, 1943 granulation tissue had appeared. No infection was present. Grafting was carried out on April 26, 1943. Thick and thin split grafts both were used. Grafts turned purplish though not as intensely as usual within 48 hours. The result was satisfactory. No loss of graft occurred (Dr. J. N. Coomb's case.)

#### EVALUATION OF METHOD

The method has the advantage of not requiring compressive dressings which not infrequently interfere with the fixation of the graft and are difficult to apply in certain areas of the body. No stitches are used and thus no fresh or additional points of bleeding are created. Likewise no stitch scars result. Furthermore the coagulum formed when the cell extract and the plasma come into contact with one

another not only fixes the graft in place but gives the cells an ideal medium to grow in. This is the same type of medium used *in vitro* in tissue culture except that the plasma and cell extract here are autogenous. The rapid growth is further enhanced by the extract from the buffy coat (leucocytic cream) which seems to have a greater stimulus to cell growth than splenic tissue extract which is frequently used in tissue culture. All solutions and media being buffered the ideal conditions for cell growth are completely realized. The coagulum helps to prevent too much exudation and, if there is any, the rapid re-establishment of the circulation takes care of this by absorption. On the 4th day the skin desquamates as if it had been sunburned but otherwise retains a normal appearance. With split skin grafts and healthy granulation tissue the edges of the graft will be seen to proliferate independently by the 10th day.

The success of the graft can be determined within 48 hours though when it is colored skin it is more difficult to determine for the uninitiated. If the surface of the undergraft, granulation tissue is unusually irregular the graft appears to smooth it out very much like



Figs 6 and 7 Case 9 Left, External surface of right leg, right, medial aspect of leg, both 48 hours after grafting



Figs 8 and 9 Case 9 Left, External surface and posterior surface of right leg, right, medial aspect of same leg, both 48 hours after second grafting and 10 days after first Patient ambulatory and discharged 19 days after first grafting

normal skin would do and the trimming of granulation tissue does not have to be quite as extensive as for other grafts. Thick skin grafts take on a deep purplish hue regularly within 48 hours, and sometimes, as in Case 6, within 38 hours. It is not essential to have granulation tissue as shown by Cases 4, 8, and 9. If the edges of the graft can be well fitted with adjacent skin as in Case 1, the rapid growth results in a very satisfactory cosmetic effect with scarcely more than linear scarring. The method has the advantage of technical rapidity, as it does not require stitching, thus time is saved for the surgeon. Fixation of the graft within 4 days permits the patient to be discharged and merely return to the clinic for observation for the next few days, thus hospital expense is saved for the individual and bed space for the hospital.

As serum does not accumulate underneath the graft, grafts are not lost because of such "floating," and no incisions need be made even in the largest grafts (15.0 by 12.5 cm) to allow for exudation. One full thickness graft (Case 6) had some fat adherent to it. Thus, in

certain cases it is hoped that tube grafts and pedicle grafts will be dispensed with, and thus again the patient will be saved long hospitalization and weeks of inactivity. To what extent this method will replace other methods of grafting, the future only can tell but experience has shown that its use is greater than was anticipated when it was first developed. Besides, the method in itself opens new fields of application which are now being developed with the co-operation of the surgical department.

#### SUMMARY

A discussion of the technique, use, and application of the new coagulum contact method of skin grafting with a report of the results obtained in 10 clinical cases is presented. A description of further simplifications of the method using dried plasma and leucocytic cream as successfully employed experimentally in animals has been reported elsewhere.

#### REFERENCES

- 1 SANO, M. E. *Am. J. Surg.*, 1943, 61: 105-106
- 2 Idem. The coagulum-contact method of skin grafting. Further simplifications. *Am. J. Surg.* 1943. In press

# UMBILICAL HERNIA IN THE BAD RISK PATIENT

WILLIAM A. WHITE, J. M.D. F.A.C.S. Boston, Massachusetts

THE value of herniotomy for the relief of umbilical hernia has been overlooked in recent years. This paper will attempt to demonstrate its usefulness as a means of reducing the needlessly high mortality in old, obese bad risk patients with large often strangulated hernias and the operation will be endorsed as the surgical method of choice in all bad risk cases. A series of 39 consecutive cases of operation for umbilical hernia in patients 60 years of age and older will be analyzed. For purposes of comparison the successful results of herniotomy in 2 private patients of 70 will be described.

The scant attention paid to herniotomy in the recent literature appears to be due to an emphasis on the avoidance of sepsis and recurrence and an underemphasis on the reduction of operative mortality. Surgeons have concentrated their attention on the technical details of operation on the choice of methods of repair and of suture materials, and the selection of the proper anesthetic with probable failure to realize that in the majority of these cases incision is better than repair, herniotomy better than herniorrhaphy.

The operation of cutting the constricting ring to relieve strangulation made its appearance in the 16th century. In 1881 Lucas-Championnière repaired umbilical hernia by overlapping the lateral edges of the rectus fascia, and 18 years later Mayo suggested transverse overlapping. In 1908 Hahn advocated a two stage operation in which between the stages binders applied increasing extra abdominal pressure to regain the lost right of domicile following weight reduction and general physical improvement the defect was repaired. In 1916 Simmons analyzed 70 consecutive cases and concluded that recurrence in adults could be reduced from 50 to 0 per cent by employing the Mayo method. In 1940 Mahorner demonstrated that the incidence of wound infection could be decreased from 20 to 10 per cent by the use of silk sutures. In 1942 Taubenschlag, advo-

cating the use of cotton thread, observed that in some cases lipectomy is necessary as a preparatory operation along with weight reduction to prevent recurrence.

The management of bad risk patients has received more attention in surgical textbooks and treatises. Bickham points out that operation should be undertaken either for relief of strangulation or for radical cure, intimating that ordinarily it should not be performed for both. Cutler and Zollinger state that all umbilical hernias in adults should be repaired if the patient's condition permits—a proviso that is too frequently disregarded. Psychologically it is difficult for a surgeon to stop short of repairing a hernia, let alone making it larger. Babcock maintains definitely that in large strangulated umbilical hernias the constriction should be relieved by incising the ring of the sac thus converting it and the abdominal cavity into one large space later after suitable reduction and preparatory treatment hernioplasty may be done. If the bowel is gangrenous Babcock recommends bringing the loop out through the incision as in the first step of a Mikulicz colostomy resection. Homans concurs by suggesting release of the ring—and often of the strangulating band within the sac—under a local anesthetic.

In September 1942 I was confronted in my private practice with 2 cases of strangulated umbilical hernia in septuagenary bad risk patients these are reported herein. Both patients were treated conservatively by herniotomy under local anesthesia. The results were so gratifying that they led to the investigation of a series of 39 such cases in which patients were operated on for umbilical hernias at the Boston City Hospital between 1932 and 1942. A great many more patients than this were admitted to the wards with this diagnosis but for various reasons the patients did not undergo surgery. In some cases the diagnosis of hernia was incidental in others the hernia reduced spontaneously or was reduced by taxis, but recurrence neces-

sitated several readmissions. Many patients were considered to be too poor risks for operation, and a few were admitted moribund. This study was limited to patients of 60 years of age and older who were operated on, since apparently the greatest improvement in treatment is to be found in this group.

The sex distribution was 31 women and 8 men, a ratio of 4:1, agreeing with that of most published series (4). On the whole, the women had larger hernias than did the men, only 2 of the latter having large defects. This observation, accompanied by the fact that most of the patients were markedly obese, corroborates the accepted theory that obesity and repeated pregnancies are the common etiological factors leading to umbilical hernia in adults.

The ages ranged from 60 to 88, with an average of 68. Twenty-four patients were in their sixties, 13 in their seventies, and 2 in their eighties. This diminishing incidence is a natural expectation with declining years. The age factor had considerable prognostic bearing within the series, the mortality rate being 2.5 times greater in the 8th and 9th decades than in the 7th.

In all the patients, whether the hernia was uncomplicated or strangulated, and regardless of other surgical procedures, repair was attempted. Twenty-six of the 39 operations were performed by members of the visiting staff, 8 by members of the resident staff, and 5 good risk cases by the house officers under supervision. The length of operation varied from 18 minutes to 2 hours and 38 minutes. The method of repair usually adopted was the Mayo procedure with "vest over pants" transverse overlapping.

The mortality rate was enlightening. Ho-mans gives an overall rate of about 30 per cent, even when the patients are in skillful hands. Wangenstein emphasizes that strangulating obstructions and late cases of simple obstruction with great distention contribute largely to the mortality. In the present series 26 patients recovered and 13 died, a gross mortality of 33 per cent. Sixteen patients were operated on electively, with 2 deaths, or 12 per cent, of the remaining 23 handled as emergencies, 11 died, or 48 per cent. The method and length of operation, rather than

skill, technique, or type of anesthesia, probably account for these disappointing figures.

The fatal cases presented a fairly constant picture. The patients were distinctly old, obese, and dyspneic. Hypertension, arteriosclerotic heart disease, fibrillation or decompensation, and chronic nephritis appeared time and again among the final diagnoses. The hernias were huge and gave rise to acute predicaments after being present for an average of 15 years. After 2 or 3 days of obstruction and acute illness, these patients entered the hospital, where immediate operation was performed. Usually either local or spinal anesthesia was employed, supplemented if necessary by nitrous oxide, ether, or cyclopropane and oxygen. The operations were tedious and disappointing. The immediate complications were surgical shock and atelectasis. There were 5 cases of major wound sepsis, 2 of peritonitis, and 1 each of septicemia and pulmonary infarct. Most of the cases, however, followed the same pattern: operation, cardiovascular collapse, bronchopneumonia, and death.

It is noteworthy that the operative findings disclosed only 2 cases of gangrenous bowel, both with a fatal termination. In one of these an area 2 millimeters wide in the transverse colon was involved in a Richter type of strangulation, in the other, 5 centimeters of small bowel, which was resected. Omentum commonly occupied the sac, and was frequently accompanied by transverse colon. When small intestine was present it was usually jejunum, a point worth mentioning because of the increased danger in high obstruction. In 5 of the 39 cases some other form of hernia was present—inguinal in 4 cases and femoral in 1. This corresponds to the incidence found by Simmons in his series.

The case of the oldest patient, a woman of 88, deserves special mention. A surgeon-in-chief advised incision under local anesthesia, without repair, but later on the same day operation was performed by one of the most capable and enthusiastic of the resident surgeons, who failed to resist the temptation to effect a repair. As a result, the patient collapsed on the operating table and a hurried, sketchy operation had to be improvised. She

recovered however and was discharged 45 days after operation. No note was made in the case report as to whether or not the rupture was cured.

The hernias ranged in size from that of a plum to that of a football. 11 were classified as small, the rest as large usually with a ring from 4 to 6 centimeters in diameter. Two-thirds of the hernias were the size of grape fruit.

The period of hospitalization averaged 23 days in the recovered cases, and 43½ days in the fatal ones.

The predominating symptoms were nausea and vomiting, crampy pain and constipation progressing to obstipation, confirming Thorek's statement that the symptoms of strangulated umbilical hernia are often only those of long standing uncomplicated hernia in an exaggerated form. Fecal vomiting was rare. The outstanding sign was tenderness of the mass itself. The hernias were tense, hard, and bluish purple or red. Distention was common. Peristalsis if present was easily seen through the thin hernial wall but this was variable. Gurgling was frequently noted. Ulceration and intertrigo beneath the redundant mass were common. In no case had the ulceration penetrated through the skin and peritoneum, as is sometimes described. Two patients had superficial burns, the result of too vigorous applications of heat previous to admission.

The white cell counts on admission varied from 7000 to 18,000, with an average of 11,000. They were of little aid in diagnosis or treatment.

It may be advisable to consider at this point some of the factors that assist one in determining the proper site of incision in umbilical herniotomy (3, 6, 12, 14). Almost invariably the hernia penetrates the abdominal wall near but not through, the umbilicus. The presence of the urachus and hypogastric arteries so strengthens the lower edge of the umbilical ring that hernial protrusions make their exit above in the region of the obliterated omphalomesenteric vein. Thus potentially weak spot yields under outward and downward strain and the lateral edges of the recti are pushed outward, with a resulting diastasis. The hard edge of the ring is below the weak

edge above often with a deposition of fat. The umbilical scar is usually found either at some distance to one side or inferior to the bulk of the protruding mass. Consequently the hernia whether for the purpose of repair or that of incision should be approached from above downward. In a simple incision, this makes the operation technically easier and obviates cutting through potentially infected, poorly healing skin.

The 2 private cases mentioned, although admittedly not constituting a series, are reported for comparison, and will be described together briefly.

Both patients were women, one 74 years old and the other 73. The former as known to have diabetes. Both were obese, arteriosclerotic, hypertensive dyspeptic, and in obvious pain. In each case the hernia had been present for many years without causing extreme discomfort. The masses were of grapefruit size and irreducible. On admission both patients had had pain, low abdominal cramps, nausea and vomiting and obstipation of 3 days duration. Repeated attempts to give enemas were unsuccessful, the fluid failing to enter by gravity; this was correctly interpreted as indicating blockage of the large bowel. There was marked distention, resulting in limited thoracic mobility, crepitant rales in the lung bases and slight cyanosis. The hernial tumors in both cases were tender and peristalsis was not visible. The skin below the masses was moderately inflamed and macerated.

In each case an emergency operation was performed as follows: One-sixth grain of morphine was given by hypodermic injection, and 1 per cent solution of novocain was infiltrated into the skin and subcutaneous tissue above and to the right of the hernial mass. A linear incision 1 centimeter in length as made in the radio of a clock. The skin, subcutaneous fat, fascia, ring, and peritoneum were incised. The contents of the sac were inspected and found to consist of viable omentum and transverse colon, and were then dropped back. The peritoneum was closed and likewise the skin, but not the ring or fascia. A large pad of sterile gauze was placed over the opening and held firmly in place by wide swath of adhesive plaster. The patients were returned to the ward in good condition, and left their beds 4 hours later. Deep breathing and body activity are encouraged at least once every hour during the time the patients are awake.

Convalescence was uneventful in both cases. Within 8 hours after operation there were multiple watery bowel movements. Gas was evacuated spontaneously and freely. The patients are out of bed daily and received no sedatives whatsoever except the initial preoperative injection of morphine. The wounds healed by first intention and the patients

were discharged home on the 12th and 10th hospital days, respectively. Both remained comfortable and were not in the least disturbed by the increase in the size of their hernias, to which they had long since been accustomed. They agreed that the result of the herniotomy was wholly satisfactory. A secondary repair was not considered necessary or advisable in either case.

On the basis of the investigation and experience here described, conservative operative management is recommended as the procedure of choice in cases of large umbilical hernia in older patients. In the later decades of life such persons neither want nor require repair of their defects, but seek surgery for the relief of obstruction and strangulation. If the high mortality in this disease is to be reduced, a minimum of surgery is essential. In all bad risk patients herniotomy is the operation of choice, with a two-stage operation in some cases if it seems desirable to repair the hernia, to eliminate failures and reduce morbidity and mortality.

#### SUMMARY

A resumption of herniotomy as the operation of choice for large strangulated umbilical hernia in old, obese, bad risk patients is advocated as a means of reducing mortality in this disease.

A series of 39 consecutive cases of umbilical hernia in old patients operated on at the Boston City Hospital is analyzed and discussed. The gross mortality was 33 per cent. The

mortality in emergency cases was 48 per cent, and increased with advancing age.

Reports of 2 cases in which simple herniotomy without repair achieved successful results are summarized for comparison.

The technique and rationale of umbilical herniotomy are described.

Conservative operative management is the only means of reducing the high mortality in this disease.

#### REFERENCES

- 1 BARCOCK, W. W. *A Text Book of Surgery*. Pp 1198-1200. Philadelphia W. B. Saunders Co., 1930.
- 2 BICKHAM, W. S. *Operative Surgery*. Vol IV, p 145. Philadelphia W. B. Saunders Co., 1924.
- 3 CALLANDER, C. L. *Surgical Anatomy*. Pp 308-309. Philadelphia W. B. Saunders Co., 1940.
- 4 CAYE, H. W. F. *Christopher A Textbook of Surgery by American Authors*. Pp 1387-1388. Philadelphia W. B. Saunders Co., 1942.
- 5 CUTLER, E. C., and ZOLLINGER, R. *Atlas of Surgical Operations*. P 38. New York Macmillan Co., 1939.
- 6 DAVIS, G. G. *Surgical Anatomy*. P 382. Philadelphia J. B. Lippincott Co., 1918.
- 7 HART, J. *Arch Klin Chir*, 1908, 85, 718-741.
- 8 HOMANS, J. *A Textbook of Surgery*. Pp 1006-1007. Springfield, Illinois Charles C. Thomas, 1935.
- 9 LUCAS CHAMPIONNIÈRE, J. *J. méd. chir., Par*, 1895, 66, 609-633.
- 10 MAJORNER, H. *Ann Surg*, 1940, 111, 979-997.
- 11 MAYO, W. J. *Ann Surg*, 1899, 34, 276-280.
- 12 MICHELSON, E., and RAFFEL, W. *Surgery*, 1941, 10, 999-1002.
- 13 SIMMONS, C. C. *Boston M. & S. J.*, 1916, 174, 342-345.
- 14 STONE, H. B. *Lewis Practice of Surgery*. Vol VII, Chap 9, 35-44. Hagerstown, Maryland W. F. Prior Co., 1943.
- 15 TAUBENSCHLAG, G. *J. Am. M. Ass.*, 1942, 118, 243.
- 16 THOREK, M. *Surgical Errors and Safeguards*. Pp 428-430. Philadelphia J. B. Lippincott Co., 1932.
- 17 WANGENSTEEN, O. W. *Surg. Gyn. Obst.*, 1942, 75, 676.

# A HALF RING SPLINT FOR FRACTURES OF THE FEMUR AND TIBIA AND FOR OTHER DISABILITIES OF THE LOWER EXTREMITY

CHARLES S. YOUNG, M.D., F.A.C.S., Los Angeles, California

THERE is need for a splint—a brace which will reduce the weight on the lower extremity in the treatment of a variety of conditions. Fractures of the femur and tibia which have not completely healed, residual paralysis following anterior poliomyelitis, spastic paralysis, osteochondritis of the superior femoral epiphysis, and lesions of the knee joint compromise the majority of these conditions. It is obvious in the use of such a brace for standing—walking that weight removed from the lower extremity must be transferred by the brace from the tuberosity of the ischium through the brace to the ground. For this purpose it has been the general custom for more than a half century to use the Thomas knee or hip splint with a caliper in the shoe, or with an extension beyond the foot. When the brace extends beyond the foot, a raise of several inches is applied to the sole of the opposite foot to remove all the weight from the lower extremity.

The writer made a study of the Thomas ring, which is the primary weight bearing part of the Thomas splint, a number of years ago. In its original form this ring was round, but later Thomas changed the shape to oval. The study showed that for weight bearing in a nonparalytic lower extremity, a round or oval ring could not be made to rest securely under the ischium. Instead, a round or oval ring has the body weight applied to it through the adductor muscles near their origins (chiefly the gracilis and adductor longus) and the medial edge of the inferior surface of the tuberosity of the ischium. When the patient attempts to walk, the ring becomes dislodged from the edge of the ischium by the action of the hamstring muscles at their origin and is displaced into the ischio-rectal fossa. Then the weight on the ring is applied through the adductor muscles and the structures in the ischio-rectal fossa. If the ring is very large there may be pressure on it by the perineum also.

It is hard to explain the curious custom of Thomas to place the ring of the Thomas splint in the excessive oblique position of 55 degrees from the horizontal. Others have increased this obliquity so that it is not uncommon to see the plane

of the ring more oblique than Poirart's inguinal ligament. A disadvantage in this obliquity of the ring is the fact that abduction of the hip is obstructed by the lateral side of the ring contacting the soft parts overlying the lateral surface of the ilium. A possible explanation seems to be that since it is technically impossible to fit a round or oval ring securely under the ischial tuberosity, brace-makers have empirically placed the ring in an oblique position to have a concave segment of the ring to act as a sling under the adductor muscles and ischio-rectal fossa, in an effort to relieve some of the discomfort. Only a small part of the weight which is normally carried by a lower extremity can be borne by the adductor muscles, the ischio-rectal fossa, or the perineum on account of the pain caused by pressure on the padded metal ring of the Thomas splint. The discomfort can be relieved by shortening the brace until practically no weight is carried on it, this being a common device of some brace-makers. In rare cases, as has been pointed out by surgeons in their vain effort to make an oval ring fit securely under the ischium, the patient bears a large part of his weight on crutches to relieve the pressure of his weight on the ring. For these reasons a Thomas ring splint has not been used by surgeons in many cases when a splint to remove weight from the lower extremity is indicated.

Another obvious difficulty with the Thomas ring splint has been its use with a caliper in the shoe. The caliper is made by bending the lower ends of the side rods at a right angle and fitting them into a tunnel in the heel of the shoe. This is a rather crude means of making a joint in the splint which is supposed to move in the same axis as that of the ankle joint. However, the caliper joint moves eccentrically, so that its axis is approximately 6 centimeters distal to the axis of rotation of the ankle joint when applied to an adult of average size. When the caliper splint is used for walking, its eccentric caliper joint in relation to the axis of the ankle joint will cause the entire brace to move up and down on the lower extremity. The side bars are relatively shortened on the lower extremity as the ankle is plantar flexed or

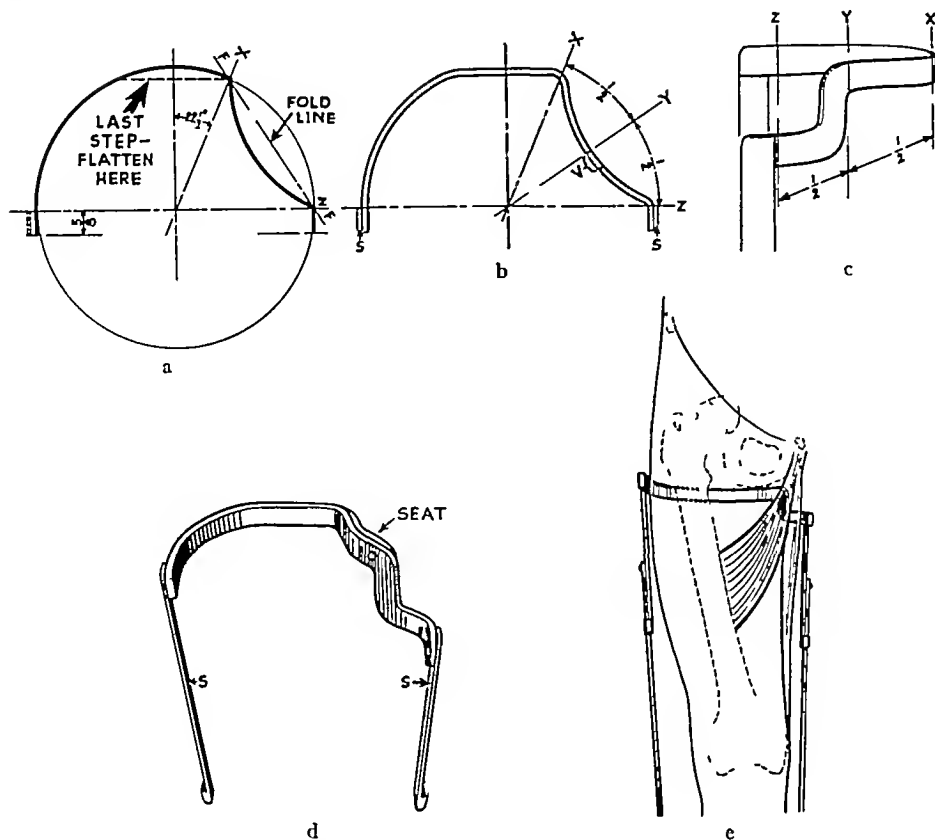


Fig 1 a, Bracemakers diagram with circle representing circumference of right thigh at perineum. Heavy line indicates pattern for metal half ring with ends extended for width of side bars. A  $22\frac{1}{2}$  degree arc is marked from the posteromedial quadrant. The arc VJ is reversed in its curve by folding the paper along fold line FF after circle is cut from paper drawing. b, Soft iron  $\frac{3}{16}$  inches by  $\frac{5}{8}$  inches bent to shape of pattern. Arc VJ represents seat for ischium. I indicates position of vertical bend downward for  $1\frac{1}{2}$  inches, the remaining part of the arc IZ being horizontal. c, Medial view showing arc VJ as the seat for the ischium and the arc IZ which is the vertical and anterior horizontal section of the ring. d, The metal half ring with side bars S attached. The seat section for the tuber ischi has an extra thickness of metal in the concavity of the curve which is held in place by two rivets. e, The half ring in position under the tuber ischi. The adductor muscles escape pressure by passing through the space anterior to the seat and the vertical section.

dorsiflexed. The side bars also move anteriorly and posteriorly in relation to the leg during these movements of the ankle joint. Therefore, a walking splint, with a caliper in the shoe and an oval ring for weight bearing by the ischium, does not conform to the principles of mechanics and should not be used as a surgical appliance.

In an effort to overcome the difficulties encountered by the use of the Thomas ring and caliper, I have endeavored to work out an ischio-bearing brace which fits positively under the tuber ischi with side bars extending to the ground, and with joints in the side bars which work in the axis of rotation of the ankle joint.

The member or part of this brace which provides a bearing surface for the ischium necessarily must fit around the upper part of the thigh, as a place to anchor the brace as a whole. However, the facts in the foregoing explain why an oval ring is far too simple in design to provide a seat for the ischium which is located deep in the soft parts of the buttock and is not superficial.

In the previous study the writer worked out a weight bearing surface on a brace which fits under the ischium in most cases, but the problem of pressure on the adductor muscles at their origin was not solved. Many of the cases used in that study were those of patients who had a residual





Fig. 2.

Fig. 3.

Fig. 2. The brace applied to patient 2, 6 weeks after transverse fracture of the middle of the shaft of the femur treated previously by skeletal traction.

Fig. 3. The brace applied to patient 4, 6 weeks after transverse fracture of the shaft of the tibia. A moulded leather cuff extends from the tubercle of the tibia to the malleoli. This cuff is not necessary in all fractures of the tibia.

poliomyelitis and in whom the postural tone of the thigh and gluteal muscles was poor or these muscles were partly paralyzed. In these cases pressure on the adductors was not a serious problem. The use of the castover in the early study was helpful but the rigid muscles were deceptive when compared to those of a subject with well developed active muscles.

Therefore changes in the shape of the original bearing surface for the ischium have been made as a result of more study and experience. The new part of the brace which provides a seat for the ischium has no resemblance to any known shape or object, as in the case of the incommensurate bone. It is called an ischio-bearing half-ring for want of a descriptive name. This rigid part is a padded flat strip of metal which fits over the posterior half of the junction between the thigh and the buttock. Part of it is bent laterally from the posteromedial side to fit under the tuber ischii. Another bend is made on the medial side of the metal in an inferior direction to allow an open space to prevent weight bearing by the adductor muscles. This ischio-bearing metal band is covered with felt  $3\frac{1}{2}$  inch thick and leather and is held in place by the side bars of the splint and by wide leather band at least 6 inches wide which is buckled between the side bars on the anterior aspect of the upper thigh. The broad leather spreads the pressure which is required to pull the seat of the half ring under the ischium. The

thickness of the felt and leather is ignored in the measurement because the subcutaneous fat is displaced sufficient to allow for it. A leather band about  $2\frac{3}{4}$  inches wide is placed between the side bars on the posterior aspect at the middle of the thigh. The function of this band is to prevent the pressure of the anterior thigh cuff from forcing the knee into hyperextension. Formerly we used metal inside of this posterior cuff. However the metal interfered with the chair in sitting and was a source of discomfort and annoyance to the patient.

Joints are placed in the side bars in the axis of the knee joint, as in other types of splints and braces. However the location of the joints at the knee are not so important because when used for weight bearing these joints are locked with sliplocks which can be loosened to flex the knee when the patient is in the sitting position. If the knee joints are placed lower than the axis of the knee joint the side bars will not project under the trouser leg in an unsightly manner.

The calf band of the brace is extended in a proximal direction in the part anterior to the side bars so that it makes pressure on the tubercle of the tibia to prevent flexion of the knee when the patient is standing.

The ankle joints in the side bars should be placed so that they work in the axis of rotation of the ankle joint. This axis is just above the joint between the talus and the calcaneus, this being

about 5 centimeters above the inferior surface of the patient's heel

In the construction of this splint, the following procedures are necessary. The circumference of the patient's thigh at the perineum is measured with a steel tape. The radius of a circle with the same circumference is calculated. To make a pattern, a circle with this radius is drawn on a sheet of paper on a drawing board (Fig 1, a). With a T square 2 diameters are drawn at right angles across the circle to make four segments. Two adjacent quadrants are designated to simulate the posterior half of the junction between the thigh and the buttock. One of these segments represents the posteromedial, the other the posterolateral side of this region. An arc of  $22\frac{1}{2}$  degrees is marked with a protractor in the posteromedial quadrant from the line separating it from the posterolateral quadrant. Then the paper is removed from the drawing board and the circle is cut out with a pair of scissors. The edge of the circular disc of paper is then folded over from the posteromedial quadrant in its medial  $67\frac{1}{2}$  degrees (line *FF*, Fig 1, a), the circumference of the circle being reversed in this part. A line is drawn on the paper to mark the reversed curve, and the paper is cut to follow this line. The remaining part of the paper with the two posterior quadrants of the disc is pasted to a piece of cardboard which is cut to the shape of the paper. This is the pattern to be used by the bracer.

The bracer takes a length of band iron  $\frac{3}{16}$  or  $\frac{1}{4}$  inch thick and  $\frac{5}{8}$  inch wide and bends it with a vise, hammer, and forge to conform to the shape of the pattern as indicated by the heavy line in Figure 1, a. A vertical bend is made as shown in Figure 1, b, c, and d. The vertical bend indicated at bracket *V* in drawing b is in the arc *XZ*. This vertical portion of the metal is  $1\frac{1}{2}$  inches long for adults and relatively shorter for children. The metal is bent horizontally then to conform to the remaining curve in the arc *YZ*. Sufficient metal must be allowed at each end of the half ring for riveting and welding to the side bars, *S*. The ring is flattened posterior as a last step so that it will not roll on the chair when the patient is sitting. In the arc *XY* which is the seat for the ischium, the metal should be made thicker for the seat by applying another section of the  $\frac{3}{16}$  or  $\frac{1}{4}$  inch by  $\frac{5}{8}$  inch metal to the concavity of the curve by the use of two rivets to hold it in place. This should be set a little high and then the entire seat section should be buffed down on its superior surface so that it is horizontal when the ring is attached to the side bars with 10 degrees' elevation from the horizontal on the lateral side.



Fig 4. A roentgenogram of the half ring used on a brace for ambulatory treatment in a case of Legg's disease. The space between the seat and the tuber ischi is obviously occupied by soft parts and padding.

The side bars *S* (Fig 1, b and d) are made of  $\frac{1}{8}$  inch by  $\frac{5}{8}$  inch spring steel. They are placed anterior to the half-ring which is set obliquely so the lateral side is 10 degrees higher than the medial side. The side bars should be adjustable for length by overlapping two sections above the knee, and below the knee also if the patient is a child.

When the brace is being applied to a patient it is important to pull the skin and subcutaneous fat overlying the tuber ischi in an inferior direction to prevent compression and pinching of a fold of these tissues between the half-ring and the bone.

The side bars should be extended and made sufficiently long to elevate the sole of the heel of the patient  $\frac{1}{4}$  to  $\frac{1}{2}$  inch above the heel of the shoe so that there is no weight bearing by the heel. If there is any doubt about weight on the heel this can be determined by a lateral x-ray picture through the shoe with the patient standing with the brace applied. The shoe should be laced last after the brace is applied, and then it will be seen

that the lacing is wider apart than the lacing in the opposite shoe. Indicating an elevation of the heel and dorsum of the foot. The amount of weight removed from the lower extremity is determined by the condition for which it is used.

#### APPLICATIONS

1. Fractures of the femur and tibia when union is incomplete when there is a delayed union, and in nonunion after bone transplantation. When a reasonable amount of callus is visible in a roentgenogram the brace may be applied to allow a small amount of weight to be applied through the forefoot but to prevent bending of the bones at the fracture site by excessive weight. The splint is useful in fractures of the shaft of the tibia. Instead of a cast and walking iron which should never be used in such cases. The splint can be used in all types of fractures of the femur including fractures of the femoral neck when there is a delayed union. When fractures are almost completely healed the slip-locks at the knee can be kept released to allow movement in the joint when walking the brace will continue to give some protection.

2. Residual anterior poliomyelitis, in which there is severe paralysis of the thigh and gluteal muscles. It is especially useful in patients with an almost total paralysis of the lower extremities as in dangle legs. In these cases it is not necessary to elevate the heel above the heel of the shoe. The brace should be sufficiently long to prevent undue flexion or hyperextension of the knee. The trunk is stabilized by resting the ischium on the half ring seat.

3. Spastic paralysis with severe involvement of one or both lower extremities. The brace is used to prevent undue flexion contracture at the knees and hips. The patients can get about with or without crutches. By maintaining the knee in an extended position the brace also helps to prevent flexion contracture at the hips because it helps the patient to stand and walk.

4. Osteochondritis of the superior femoral epiphysis or of the acetabulum. This brace has

been used in cases of Legg Perthes disease, in cases of slipping femoral epiphysis, and in osteochondritis of the acetabulum after the acute stage was treated by recumbency with traction or in plaster spica. It allows these patients to be ambulatory with an assurance that they are not being made worse by weight bearing. In our experience healing occurs with less deformity because the brace allows function with a minimum of weight on the joint structures.

5. Knee joint lesions. Following arthrodesis of the knee in tuberculous disease of the joint the brace is used to allow partial weight bearing and prevent flexion or other deformities after removal of the plaster spica during the process of fusion of the femur and tibia. This brace has been used in some cases of atrophic arthritis of the knee joint to prevent flexion contracture and restore the function of walking.

#### SUMMARY

1. A splint or brace extending from the tuber ischii to the ground is useful to remove all or part of the body weight from the lower extremity in a number of pathological conditions, fractures of the femur and tibia being the most common of any of these.

2. An encircling band around the thigh at its proximal end must provide a seat for the tuber ischii. However a simple round or oval ring cannot fit under the tuberosity of the ischium because the area nearest it is concave instead of being convex.

3. A padded half circle of flat metal, bent to fit anatomically under the tuber ischii, is described for application to side rods which extend to the ground through the shoe heel. The half ring is held in place by leather which is buckled between the side bars anteriorly.

#### REFERENCES

- ARTHUR, D. M. Hugh Owen Thomas, His Principles and Practice. P. 6. London: H. K. Lewis, Ltd., 1935.  
 OGDON, C. S. J. Am. M. Ass. 920, 91 602-603.

# RECONSTRUCTION OF BREAST DEFORMITIES

HANS MAY, M D, F A C S, Philadelphia, Pennsylvania

**B**REASTS are deformed, according to the female patient, either because they are hypertrophic—or in rarer instances—too small. The etiology of either type is not well understood. It is probably the result of endocrine dysfunction. In the hypertrophic type, additional factors such as pregnancy or obesity may lead to the deformity.

McIndoe divides the hypertrophic forms in 5 types (1) Long, heavy, pendulous breasts with hypertrophy of the most dependent glandular portion, characteristic of the adolescent girl of otherwise normal build. This is probably purely endocrine in type. (2) Broad, heavy breasts associated with obesity and aggravated by pregnancy. This is probably of more complex endocrine origin. (3) Sac-like dependent breasts following obesity reduction of the second variety or multiple pregnancies in the first. (4) True gynecomastia. Marked hypertrophy of the glandular elements of the breasts results in one of enormous proportions. These cases are not common, but are purely glandular in origin and related to type one. (5) Asymmetry.

A number of operations have been devised for reconstruction of breast deformities. An exhaustive and well illustrated review of the various operations has been published by Biesenberger and most recently, by Thorek. Each method has advantages and disadvantages.

## OPERATION FOR HYPERTROPHIC, PENDULOUS BREASTS

The reconstructive operation for pendulous breasts should fulfill two purposes: first, correct the deformity; second, maintain the function of the gland.

*a One stage operation for moderately hypertrophic breasts (Lever's method)* (Fig. 2). This method has been described previously by the author (7). The method is applicable for moderately hypertrophic breasts or those breasts which consist of a flabby sac of skin with scanty breast tissue at the bottom. It is performed on both sides at one sitting.

In large hypertrophic pendulous breasts, however, a two stage procedure is safer so as not to endanger the circulation of the areola. In those cases Lever advises resection of some of the breast tissue during the first stage of his operation and of the other part in a second stage four weeks later.

This means two major operations. To change the second stage from a major to a minor stage, I devised a procedure a description of which follows.

*b Two stage operation for hypertrophic, pendulous breasts (author's method)* (Fig. 1). The blood supply of the breast is derived from three sources: branches of the arteria axillaris, of the mamma interna, and arteriae intercostales. According to Cruveilliers, Kaufman, and others, the third and fourth branches of the arteria mamma interna carry the main blood supply, not only to the gland but also to the areola. While the branches of the arteria axillaris supply only the lateral superficial parts of the breast, the intercostal arteries are insignificant (Anson, Wright, and Wolfer). Thus, the areola receives its blood supply from beneath—from branches of the arteria mamma interna—and also from the surrounding skin. If the areola is separated from the surrounding skin but left attached to its base, a sufficient blood supply is guaranteed from beneath. If, however, in addition to the skin incisions, much breast tissue needs to be removed, the deep blood supply of the areola may become insufficient unless proper precautions are taken, i.e., resecting only the lateral parts of the breast tissue, leaving the median half intact to form a median pedicle (Biesenberger, and Gillies and McIndoe), leaving the areola attached to an epidermis freed pedicled flap (Schwarzmann), etc.

A two stage procedure (Fig. 1), however, seems to me the safest way to counteract any variability of the blood supply and thus to avoid nipple necrosis. The simplest way to counteract any circulatory disturbance of the areola is the formation of a bridge—or double pedicled flap—in which the distal pedicle is the areola, which remains anchored to its base. The flap comes to lie above the areola and consists of that part of the skin which in Lever's procedure, is removed (compare with Fig. 2a-d). Such a flap carries sufficient circulation to safeguard the viability of the areola if much breast tissue must be removed. The flap is removed in the second stage of the operation about two weeks later.

The operation is carried out as follows (Fig. 1, a-e): the first stage is performed under general anesthesia, the patient is in a half sitting position. The two points to which the nipples are to be transferred are marked with a drop of methylene

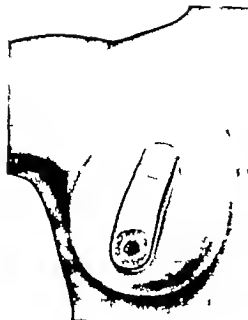


Fig. a.

Fig. a. The point to which the areola is to be transferred is marked with drop of methylene blue. An ordinary medicine glass is used as pattern and placed over this point and its rim is outlined with the dye. The medicine glass is now placed over the nipple and its rim outlined on the areola. The most lateral and median points of both



Fig. b.

outlines are connected with each other by an incision. b. Between both incisions the skin and subcutaneous tissue (not the areola) are undermined to form bridge flap. Another incision is carried around the lower half of the areola. Note outline of curved incision in lower half of breast.

blue injected intracutaneously. An ordinary medicine glass placed over this point is used as a pattern and its rim is outlined with a dye. The medicine glass is now placed over the nipple and its rim is outlined on the areola. The most lateral points of both outlines are connected with each other by an incision. Another incision parallel to the former connects both median points. Between both incisions, the skin and subcutaneous tissue (not the areola) are undermined to form a bridge flap. An incision is now carried around the lower half of the areola after the surrounding skin is undermined and separated, the areola, which is left in contact with its base, is lifted upward and connected with the upper pedicle of the bridge flap with sutures. Then it is fastened to the surrounding skin with subcutaneous and skin sutures. Both halves of the bridge flap are fastened to each other with a few skin sutures. The next step consists of an incision of the skin beneath the areola in continuation of the upper cuts, not parallel, but in diverging curves. The terminal points of the incisions should lie at least one inch above the mammary fold, not within the

fold because the fold of the breast after reduction of its size becomes displaced upward. Between both incisions lies a triangular-shaped piece of skin which is dissected downward and forms a flap (center flap) for later use. The next step consists of separation and blunt dissection of the skin from the lateral and median lower halves of the breast, care being taken not to carry the dissection too far. The hypertrophic parts of the breast are now bulging more laterally and median than below the areola. The parts bulging lateral to the areola are now grasped and excised in a wedge-shaped form, as outlined in Figure d. The same is done on the median side. Thus, center bloc of breast tissue is left, to which the lateral and median wound edges are attached with heavy chromic catgut sutures. In the words, the center part which carries important vessels is left intact; it is simply lifted upward. If it is still bulging, it may be shaved off to proper size. The lowest lateral and median sutures attach the breast to the pectoral fascia. The surrounding skin is now trimmed to conform to the lower half of the areola and breast and sutured together with two rows of sutures.

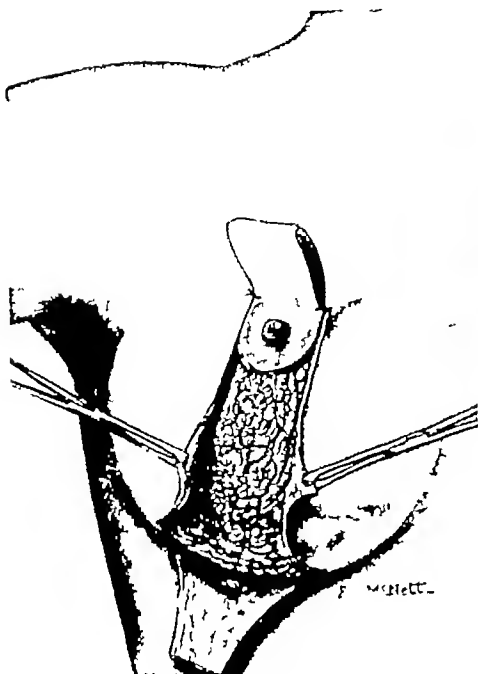


Fig 1c

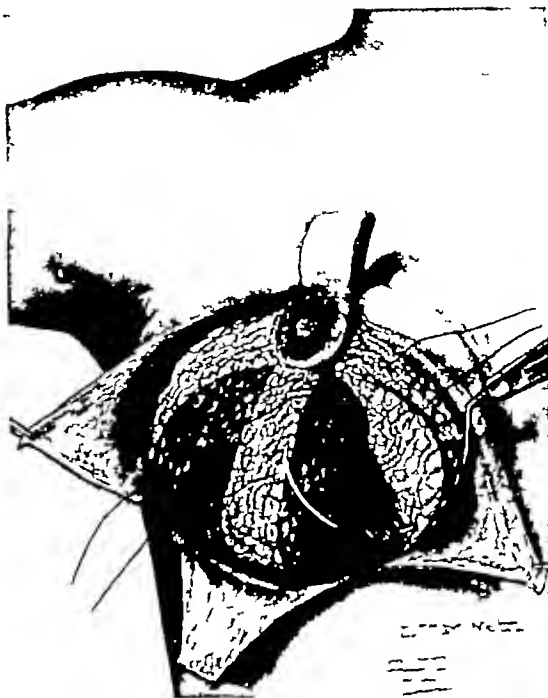


Fig 1d

Fig 1 c, After the undermining and separation of the surrounding skin the areola which is left in contact with its base is lifted upward and connected with the upper pedicle of the bridge flap with sutures. The next step consists of an incision of the skin below the areola in continuation of the upper cuts, but in diverging curves. The terminal points of the incisions should be at least 1 inch above the mammary fold because the fold of the breast after reduction of its size becomes displaced upward. A triangular shaped piece of skin between both incisions is dissected downward to form a flap for later use. d, Separation and blunt dissection of the skin from the lateral and median lower halves of the breast. The hypertrophic parts of the breast bulging laterally and median are grasped and excised in a wedge shaped form. Thus, a center block of tissue is left to which the lateral and median wound edges are attached. This center part acts as a buttress and a carrier for important vessels. If it is still bulging it may be shaved off to the proper size. The lower sutures attach the breast and the pectoral fascia. e, The surrounding skin is now trimmed to conform to the lower half of the areola and breast and is sutured together with 2 rows of sutures (subcutaneous and skin sutures). The bridge flap is separated in the same stage and the areola adjusted in place if clamping of the flap does not result in discoloration. If however, discoloration becomes evident, this flap is removed 2 weeks later.



Fig 1e

(subcutaneous and skin sutures). Finally the center skin flap is trimmed and sutured to the lateral and median flaps. A drain is placed in the lateral corner. The same operation is performed on the other side. A firm compression dressing is applied to both breasts, care being taken that the

pedicles above the areola are free from any pressure, otherwise, necrosis of the nipples may result.

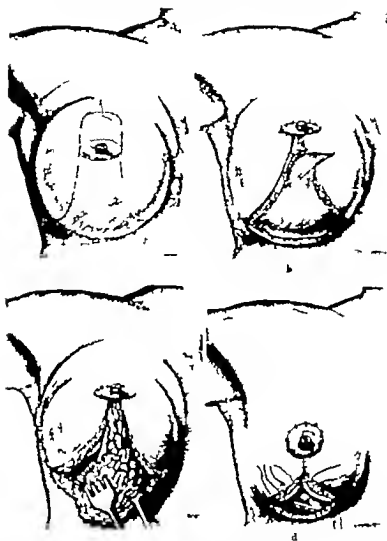


Fig. One stage plastic of the breast. a, Incision around the nipple; the parts of the skin to be removed are outlined; the pin marks the place where the nipple will be transferred. b, The nipple is transferred into the upper corner of the wound. Excision of the hanging tissue. c, Closure of the wound in layers. (Courtesy: *Textbook of Surgery*, 30, 35, 36.)



Fig 3 a, left, Patient, aged 29 years, married, with 2 children, has pendulous breasts b, One year after a one stage breast plastic

c There is another possibility. If, due to reasons as stated later, a plastic amputation of the breast is performed, one may be able to transplant the areolae. If this is planned, the bridge flap is raised and returned to its base in the first operation as here described. In the main operation 3 weeks later, the flap is raised and the distal pedicle, i.e. the areola, is separated from its base, thus converting the bridge flap into a single pedicle flap with the areola at its peripheral end. The plastic amputation is now carried out and at the end of the operation, the areola is sutured into the upper wound edge, the picture now resembles that which is seen in Figure 1, c, separation of the bridge flap is carried out 2 weeks after amputation.

d There is still another possibility of using the bridge flap, this was discovered through a rather sad experience. The following case presents an instructive example. This patient had very large, hypertrophic, pendulous breasts (Figure 5). A three stage operation was performed as described. The usual pressure dressing was applied, care being taken to leave the flaps free of any pressure. Some bleeding occurred after the operation, and the attending nurse called the house physician, asking him for advice. She was told to reinforce the dressing. When the patient was seen the next day, one turn of the figure-of-eight dressing included the lower half of the left bridge flap, resulting in complete necrosis of the left areola. Later on, the areola was excised and the upper half of the bridge flap which remained intact was used to cover the defect. Thus, it may be noted that, in spite of all precautions which are taken, the areola or a portion of it becomes necrotic, parts of the flap may be used to cover the resulting defect.

#### PLASTIC AMPUTATION

Under plastic amputation is understood an operation by which the greater parts of the breast, including the areola, are removed and the remaining parts of breast tissue and skin are used for recreating a natural shape. Indications for such an operation are various: enormously large breasts (hypertrophica vera, first described by Billroth), large, hypertrophic breasts with poor circulation, large breasts without function. It has been feared that a plastic amputation may lead to cystic degeneration and other disturbances, this can hardly be true in those breasts which are without function. Patient, 30 years of age, had very large breasts, both were cyanotic and displayed several flat scars from superficial ulcerations (Fig 6). She had one child, but did not lactate at that time. A bilateral plastic amputation was performed. Five years later she delivered another child, neither breast showed the slightest evidence of function. There are cases reported in literature (Hollander, Sebening, Schwarzmann) in which



Fig 4 a, left, Patient, aged 10 years, hypertrophic pendulous breasts had a two stage breast plastic performed b, The result 2 1/2 years after the operation. Patient wore brassiere size 44 before operation, now wears size 34



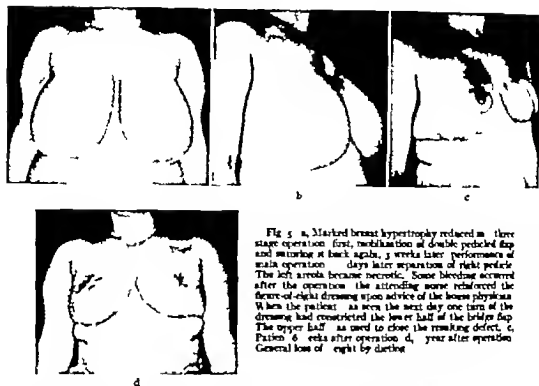


Fig. 5 a, Marked breast hypertrophy reduced in three stage operation: first, mobilization of double pedicle flap and suturing at back again, 3 weeks later performance of final operation—days later separation of right pedicle. The left areola became necrotic. Some bleeding occurred after the operation—the attending nurse reinforced the figure-of-eight dressing upon advice of the house physician. When the patient—as seen the next day one turn of the dressing had constricted the lower half of the bridge flap. The upper half—as used to close the remaining defect, c. Patient 6 weeks after operation d, 1 year after operation. General loss of weight by dieting.

even in functioning breasts from which the nipples were absent no pathological disturbances occurred during and after pregnancy. Some of the cases were followed up for many years. In one of the author's cases the function of the gland could be promptly stopped after administration of 5 milligrams of stilbestrol three times a day soon after delivery.

The operation is performed similar to the one stage operation after Lexer (Fig. 2). The point to which the nipples are to be transferred is marked. From this point two curved diverging incisions are made similar to those in the ordinary one stage operation (Fig. 5b-d). Skin, nipples, and breast tissue lying between these incisions are removed *en bloc*. The resulting wound is closed in layers.



Fig. 6 a, left, Woman, aged 30 years, with marked hypertrophy of breasts not enlarged since scars, and trophic ulcer patient had a child, did not lactate at that time. The local disturbance of circulation as contraindication for breast plastic. A plastic amputation—as performed. Five years later she delivered another child, neither breast showed evidence of function.

In some cases, the areola may be preserved and transplanted in a way as described previously, or, according to Thorek, may be excised from its underlying structures and transplanted as a free graft into the upper wound corner after this place has been properly excised and prepared to receive the graft. Thorek emphasizes the importance of making the excised hole smaller than the graft, thus allowing for shrinkage of the graft.

#### RECONSTRUCTIVE OPERATION IN SMALL BREASTS

Indications for such an operation are smallness of breasts due to removal of breast tissue (cystic mastopathia, tumor), and genuine small breasts (hypomastia). Czerny, as far as can be ascertained, was the first who performed a reconstructive operation for correction of a small breast. For an actress, from whom cystic tissue of the left breast had been removed, he replaced it by a lipoma which the patient had accidentally in her lumbar region. The breast remained well formed, the lipoma did not grow.

If the breast deformity is unilateral as it may be in postoperative cases, and the other breast is large, the large breast may be reduced by a breast plastic and some of the resected tissue transplanted into the small breast. If this is impossible, a fat tissue graft should be used. In genuine small breasts (hypomastia) hormone treatment should be given a trial (MacBryde). If it fails, fat tissue should be transplanted. The graft is preferably taken from the thigh. It is advisable to take the graft two-thirds larger than required to counteract degeneration and shrinkage. Furthermore, it is advisable to remove some of the underlying fascia with the fat tissue graft. A recent experience makes me believe that the fascia may limit the shrinkage of the graft (Fig 7).

Four years ago a married woman, age 26, came to me with the request to increase the size of her breasts. I told her that such an operation is possible but not advisable without first having tried conservative methods in the form of hormone treatment and increase of weight. The family doctor was informed and he treated the patient along this line. She returned to me 1 year later and stated that she had gained 15 pounds, but in the gluteal region rather than in the breasts. The breasts were still atrophic, they also were functionless. She had one child, but did not lactate at that time. The operation was performed.

From an incision in the mammary folds the breasts were separated from the pectoral fascia. A large piece of fat tissue was removed from the



Fig 7 a, left, Patient with small, functionless breasts (hypomastia) hormone therapy and gain of weight failed to increase size of breasts b, Fifteen months after transplantation of fat and fascia lata from thighs beneath breasts

lateroposterior surface of the left thigh and transplanted between the left breast and pectoral fascia. A similar piece of fat was removed from the right leg, accidentally, together with some fascia lata and transplanted into the right breast. The wounds were closed in layers. All wounds healed primarily. The follow-up examination 9 months after the operation revealed shrinkage of the left graft about two-thirds of its size, while the right graft showed hardly any shrinkage. While the donor area of the left leg was filling up again, the scar on the right leg remained depressed. The explanation for this phenomenon may lie in the fact that fat plus fascia was transplanted on the right side, while no fascia was used on the left side. The left breast was operated on again, more fat tissue together with fascia was transplanted. Only slight shrinkage of the graft has occurred since.

#### SUMMARY

Reconstructive operations for correction of various forms of hypertrophic and atrophic breasts are described and illustrated.

#### REFERENCES

- 1 ANSON, B. J., WRIGHT, R. R., WOLFER, J. A. *Surg Gyn Obst.*, 1939, 69, 468.
- 2 BIESENBERGER, H. *Deformitäten und Kosmetische Operationen der weiblichen Brust*. Vienna: Wilhelm Maudrich, 1931.
- 3 GILLIES, H., and McINDOE, A. H. *Surg Gyn Obst.*, 1939, 68, 658.
- 4 KAUFMAN, R. *Bull. Soc. méd. Paris*, 1935, 139, 484.
- 5 LEXER, E. *Die Gesamte Wiederherstellungschirurgie*. Leipzig: Johann Ambrosius Barth, 1931.
- 6 MACBRYDE, C. M. *J. Am. Med. Ass.*, 1939, 112, 1045.
- 7 MAY, H. *Arch. Surg.*, 1939, 38, 113.
- 8 McINDOE, A. H. *Rev. chir. Struct.*, 1938, 8, 39.
- 9 SCHWARZMANN, E. *Chirurg*, 1930, 2, 932.
- 10 THOREK, M. *Plastic Surgery of the Breast and Abdominal Wall*. Springfield, Ill.: Charles C. Thomas, 1942.

# USE OF FASCIAL SUTURES IN INGUINAL HERNIA

CLAUD C. BURTON, M.D., F.A.C.S., Dayton, Ohio

THE importance of fascial sutures in the repair of difficult inguinal hernias with large parietal defects can hardly be exaggerated. Moreover their usefulness has steadily expanded from their initial employment in hernioplasty to almost all allied surgical fields. Fascia is used in the mobilization of stiff joints and the stabilization of subluxated ones, the retention of fragments in certain types of fractures, particularly of the patella and olecranon process, in the re-establishment of incontinent sphincters, in the suspension of ptosed kidneys and occasionally in internal neurolysis.

The superiority of fascia over catgut suture and other non-labile sutures lies in the fact that it possesses great tensile strength, is nonirritating, remains viable for many years and may be used where there is special need for tendinous, ligamentous, or fascial replacement. Why it has been so slow in attaining its present enviable position may be attributed to lack of knowledge concerning its histological evolution in its new environment, the mechanical difficulties experienced in its proper placement necessitating the development of large-eyed and more sturdy needles, and the obstacles encountered in the procurement of the free fascial suture.

To understand better the paucity in the general acceptance of living sutures it is necessary to recall for comparative purposes the extent of contemporary development of the allied sciences, histology, pathology, physiology and anatomy, which were not co-ordinated then as they are today. It was not the custom, nor was it possible in that era to do extensive research on the plausibility of theory. Our thinking was directed more toward practical realism and clinical application. Laboratory research had not developed to the point where it was serving as the proving ground of new ideas and new techniques.

McArthur in 1900 was the first to conceive and make practical application of a living suture. He employed a pedicled suture taken from the rent edge of the external oblique psoas muscle which he used as a running suture in apposing the conjoined tendon to Poupert's ligament as the first step in the repair of an inguinal hernia. Despite

the success attending McArthur's innovation and the soundness of the principle which was destined to play an important rôle in plastic surgery the profession was loath to accept it because as yet the only real question concerning the fate of the autogenous suture could not be answered unequivocally and quite naturally there was some basis for the existent skepticism of many surgeons.

Almost a decade later Klinebner in 1909 performed some experiments using tendinous and fascial grafts and observed that these transplants retained their gross and histological characteristics. This was followed by more careful studies of fascial sutures by Lewis (3, 12) and his associates in 1916 and 1917. However autogenous fascioplasty received its greatest impetus from the publications of Gallie and LeMesurier (3, 4, 5). The experimental observations of these two investigators with their carefully followed representative group of cases, many of them having been successfully operated upon by other methods were so convincing and the results so gratifying that the evidence seemed almost irrefutably in its own favor of lasting viability of the suture. Statistical reports from many sources have corroborated the principles of Gallie's technique which is generally accepted as the procedure of choice in the repair of recurrent and difficult hernias. However it is unsafe to disregard other essentials of the operation and assume that the fascial suture alone is a panacea for all hernias. Nevertheless, it is decided improvement over other contemporary methods and offers cures to a group of patients who hitherto had been considered hopelessly incurable many of them otherwise physically strong.

On the other hand there have been adverse reports on the use of living sutures with higher recurrence rates and a few surgeons have abandoned their use. Yet, in spite of an occasional unfavorable report living sutures are gaining in popularity. I am referring to viable fascial strips as distinguished from preserved dead fascia of Koontz and Nagerott and subsequently applied to man by Glawer, Egan, and others. Moreover it has been demonstrated that heteroplastic grafts behave like catgut and have short survival period.

The fascial technique has also been condemned on the ground that owing to the size of the suture

Published with the permission of the Medical Director, Veterans Administration who assumes no responsibility for the opinions expressed or conclusions drawn by the author.

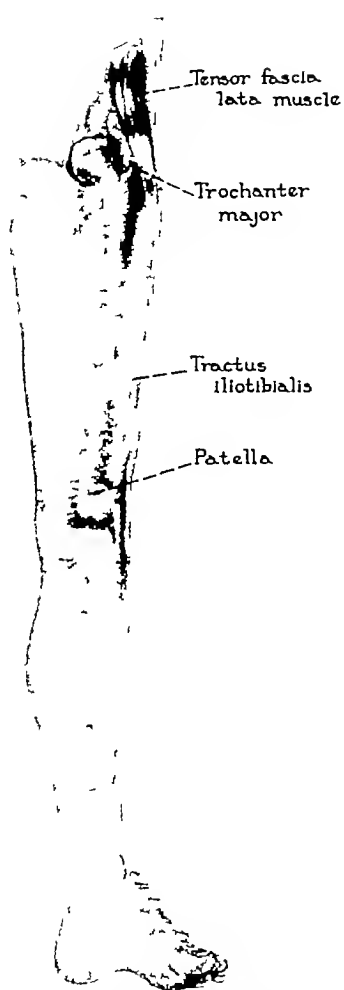


Fig 1 Lower extremity, anatomical relationship of iliotibial tract

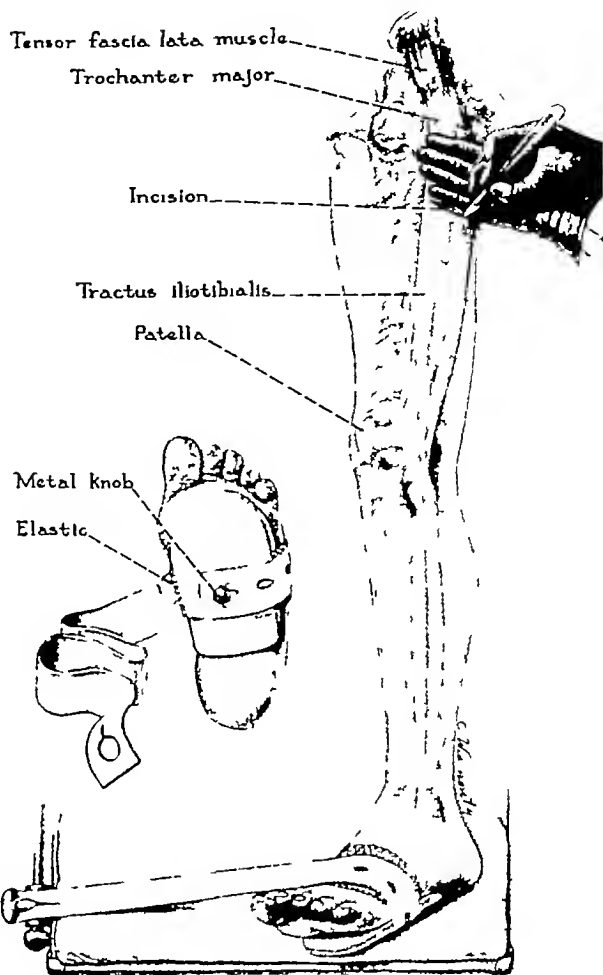


Fig 2 Detail of the sandal in use, the location of the incision is also illustrated

It is cumbersome to handle, produces trauma, and sometimes tears the tissues. This accusation is true in a relative sense only. It is assuredly untrue clinically provided the proper sized suture is selected and care is exercised in its placement. The needle should be passed, clearing the inguinal ligament, reversed, and passed back, forming a vertical loop which can be done without the knot hanging as it is drawn through the ligament. If the suture is forcibly passed through the ligament, out and in with a single stroke, it is more likely to produce tearing and not infrequently the suture is pulled with such violence that it is jerked free of the needle. Such practice brings disrepute on a valuable method. Another point worthy of men-

tion is to insert the needle under the loops of the first fascial suture and not through the ligament when imbricating the aponeurotic flaps.

Fascial sutures may be either pedicled or free depending upon the nearness of the donor site. The former is procured from adjacent structures and does not require an additional incision. Those who have sponsored this source of obtaining the suture include McArthur and Joyce, who used a single suture, Robins and Sachs, who prefer a double suture taken from the lateral and median edges of the external oblique aponeurosis, and Hodgkins, who employs multiple interrupted sutures raised from the anterior sheath of rectus. A disadvantage of pedicled sutures is the chance of

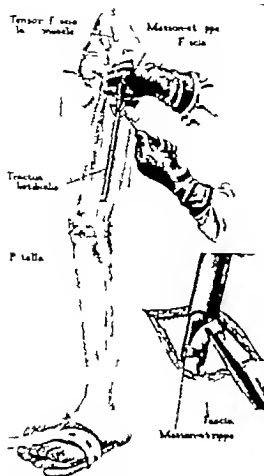


Fig. 3. Extraction of fascial strips with the Mason strip.

compromising the function of the contributing stratum and indirectly jeopardizing the repair by substituting a potentially vulnerable area in lieu of the original hernial weakness. Another disadvantage although remote is the possibility of underestimating the extent of the parietal defect, and the surgeon suddenly finds himself confronted with the need of additional sutures but is unprepared at this stage of the repair to remove free fascial strips. Such a dilemma occurred often enough that it led to more frequent use of the Gallie principle of using fascial strips taken from the lateral surface of the thigh.

Progress in the use of fascial strips is dependent not only on their intrinsic physiological and anatomical superiority in the repair of parietal de-

fects but on mechanical refinements in obtaining them. Through cumulative experience with this technique we have devised an appliance to facilitate the removal of strips from the iliofemoral tract. It does not replace the Mason stripper rather it complements it. Wangenstein suggested placing under the hip of the side operated upon a sand bag which elevates the thigh and gives better exposure of its lateral surface where the fascia is densest. The greater accessibility is particularly valuable when raising massive pedicled grafts. Unfortunately this maneuver does not correct the external rotation which the thigh naturally assumes at rest or under anesthesia and which is more important than tilting the hip. To maintain internal rotation of the limb we devised a sandal (Fig. 3) in which the sole is fashioned of one fourth inch thickness of light wood, on the bottom of which is a small metal post placed at the level of the proximal metatarsal heads to which is attached an adjustable canvas strap. This strap passes around the outer side and then across the dorsum of the inverted foot which is fastened to the opposite side of the operating table. The sandal is held secure on the foot by an elastic band which is affixed to its forepart and therefore accommodates to any size foot without impairing the circulation or producing any pressure points. We have not had a patient complain of any discomfort or after effects from wearing the sandal. It is easily applied, simple to construct, in fact it can be made in a few minutes and of material available in any operating room. After the anesthetic is given, usually spinal, the sandal is slipped over the inverted foot with the femur rotated inward. The adjust-

able strap is fastened to the opposite side of the table with sufficient tautness to maintain inversion of the limb. Figures 2, 3 and 4 illustrate the mechanical sandal I use and the extraction of fascial strips with the Mason stripper. By maintaining the femur in internal rotation the stripper can be held parallel to the vertical and longitudinal planes of the thigh which enhances the smoothness with which it is passed and there is less likelihood of tearing the strip or altering its size before reaching the desired length. Since developing the sandal we no longer place a sand bag under the hip. We belong to the school of enthusiastic believers in the superiority of living sutures and have been using the mechanical sandal more than 6 years with considerable satisfaction. The sandal is applied in every hernia repair and the thigh is prepared routinely so that we are not delayed in the event fascial suture is considered indicated. So far as I know there has been no other similar appliances for this purpose.

In an analysis to assess the value of the fascial suture technique in inguinal hernias we must not only compare the recurrence rate of the hernia but must include any complications arising at the donor site. In a consecutive series of 1,810 inguinal hernias operated upon in the past 5 year period (1938-1942), we have employed the Gallie repair 385 times, 321 of which were followed 1 to 5 years. In this group there were 3, or 0.9 per cent, recurrences, 3, or 0.7 per cent, infections, which persisted until the silk suture or fascial remnant was removed, 3, or 0.9 per cent, testicular atrophies, and 5, or 1.2 per cent, hematomas of the thigh which were promptly evacuated without delaying the patients' convalescence. There were no herniations through the defect in the iliotibial tract, or other complaints at the donor site. One death occurred in this series but at postmortem it was found to be unrelated to the hernioplasty.

A similar analysis of 132 McArthur repairs performed during the same period showed that there were 6, or 4.5 per cent, recurrences, 3, or 2.2 per cent, infections, no testicular atrophies, no hematomas, and no deaths.

In 1940 we (16) published follow-up studies on 457 herniorrhaphies using silk exclusively with a recurrence rate of 7.5 per cent. Therefore, it would seem from these comparative studies the fascial suture technique has a decidedly lower recurrence rate.

#### SUMMARY

The evolution of fascial sutures has been discussed, setting forth reasons for tardiness in their general acceptance.

The advantages and disadvantages of living sutures have been commented upon.

The importance of the Masson stripper in simplifying the procurement of multiple sutures has been emphasized.

A new foot inversion appliance consisting of an easily made mechanical sandal to facilitate the

removal of fascial strips is illustrated and its use described.

A follow-up study of a series of 517 cases of inguinal hernias, repaired with autogenous fascial sutures, is submitted. The recurrence rate of 0.9 per cent (Gallie) and 4.5 per cent (McArthur) is statistical verification of their value in hernia repair. In our hands, it represents a substantial lowering of the recurrence rate as compared with other methods. We do not wish to minimize the complications. The 3 testicular atrophies and 5 hematomas occurring in this group must be taken into consideration in the final assessment of this technique. However, with increasing experience it is believed these complications can be reduced. Moreover, it should be remembered that the fascioplasty was used in recurrent and more difficult hernias occurring in patients of the fifth and sixth decades.

#### REFERENCES

- 1 BURDICK, C. G., GILLESPIE, DAVID, H. M., and HIGINBOTHAM, N. L. *Ann Surg*, 1937, 106 333
- 2 EGAN, M. J. *J M Ass Georgia*, 1935, 24 317
- 3 GALLIE, W. E., and LEMESURIER, A. B. *Canad M Ass J*, 1921, 11, 504
- 4 *Ibid*, 1923, 13 460
- 5 *Idem Arch Surg*, 1924, 9 516
- 6 GLASSER, S. T. *Am J Surg*, 1933, 19 542
- 7 HODGKINS, EDWARD M. *Surg Gyn Obst*, 1928, 47 831
- 8 JOYCE, THOMAS M. *J Am M Ass*, 1940, 115 971-976
- 9 KIRSCHNER, M. *Verh Deut Ges Chir*, 1909, 38 281
- 10 KOONTZ, A. R. *Ann Surg*, 1926, 83 523
- 11 LEWIS, DEAN D. *Lancet Clin*, 1916, 115 300
- 12 *Idem Surg Gyn Obst*, 1917, 24 127
- 13 MASSON, J. C. *Minnesota M*, 1935, 18 485
- 14 MCARTHUR, L. L. *J Am M Ass*, 1901, 37 1162
- 15 NAGEOTTE, J. *C rend Acad sc*, 1920, 170 1523-1525, 1925
- 16 RAMOS, RAOUL L., and BURTON, C. C. *Surg Gyn Obst*, 1940, 70 953-957
- 17 ROBINS, CHARLES R. *Ann Surg*, 1938, 108 389
- 18 SACHS, LOUIS. *Surg Gyn Obst*, 1939, 69 515
- 19 WANGENSTEEN, O. H. *Surg Gyn Obst*, 1934, 59 766

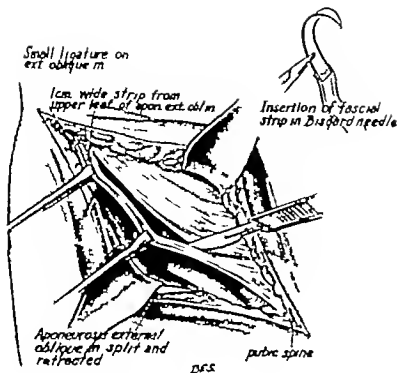
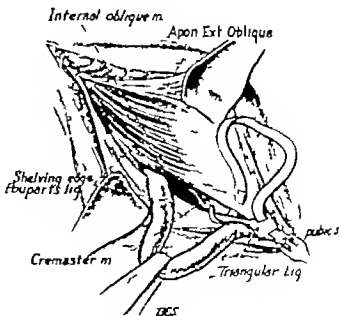


Fig. Details of stripping the fascial sheath from the upper leaf of external oblique aponeurosis. Insert shows method of anchoring the fascial sheath Bissford' needle.

Fig. 3 This drawing shows technique of taking the first bite through the triangular ligament. (This figure should be shown the cremaster included in the continuous suture.)



# LIVING FASCIAL SUTURES IN THE REPAIR OF INGUINAL HERNIA

WILLIAM JOHN RYAN, A B, M D, F A C S, Philadelphia, Pennsylvania

SINCE McArthur first advocated the use of fascial sutures in the repair of inguinal hernia, many methods for its use have been described. Unfortunately many of the methods have gotten away from the simplicity of the fundamental procedure, and a simple operative procedure has thus been made a complicated one.

Boland believes in the fundamental soundness of the Bassini technique. We agree with him but would like to add that the fundamental principle of the Halsted procedure is also sound. If to them is added the simplest method of using living fascial sutures in the main step of repair, there is evolved a simple, fundamentally sound, surgical method of repairing both direct and indirect inguinal hernia.

Roughly, about 11 per cent of all inguinal hernias are direct. Andrews believes that it is unfortunate that the term "inguinal" should group the direct and indirect types together. It is well known that a direct inguinal hernia is a simple bulging of the peritoneum and transversalis fascia into the posterior aspect of an inguinal canal which is not perfectly formed or developed. It has no relation to the cord or to the descent of the testis. It does not come through the inguinal canal. Perhaps some other term would more appropriately describe it.

Several years ago while we were teaching operative surgery at the Woman's Medical College of Pennsylvania, using human cadavers for demonstration, Dr. Alma D. Morani, my assistant, and I undertook to study the feasibility of using some simple type of operation in which successful repair could be made with living fascial sutures. The literature was reviewed and numerous methods were tried. We finally decided that a strip of fascia split off the upper leaf of the aponeurosis of the external oblique, with its lower end attached to the spine of the pubis, was the simplest and most efficacious. The use of this strip was not original with us. A Gallie needle was used in the first several cases, later, however, Bisgard devised a needle and this has since been used in all cases.

## TECHNIQUE

The operative technique must be carried out carefully in every detail. Meticulous attention to anatomy and hemostasis and careful, gentle handling of the tissues are necessary, sharp dissection is always preferable to blunt dissection and the "wiping away" of adjacent tissues. Spinal anesthesia is used in all cases unless there is some definite contraindication. The incision begins just inside the anterior superior spine and is carried down just above Poupart's ligament and over the symphysis pubis so that the upper and anterior aspects of the spine of the pubis are exposed. At this point the procedure is slowed down a bit, so that if possible, all vessels may be clamped doubly and cut between. Both sides of the incision are separated widely and retracted well. When the external oblique aponeurosis is exposed, all areolar tissue is dissected from it very carefully until the full width of the aponeurosis can be seen in the wound, as well as its full length.

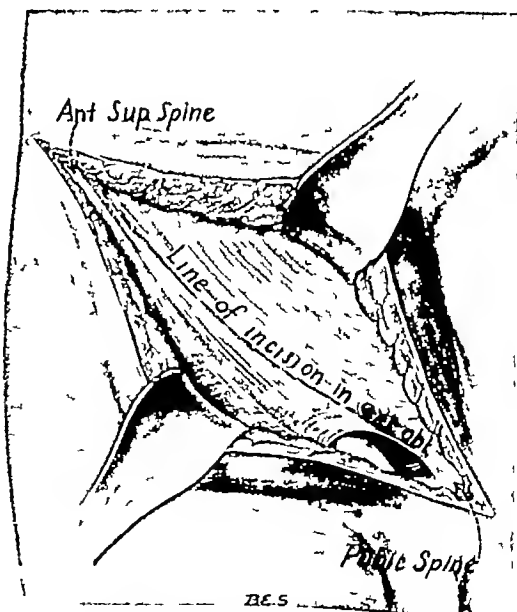


Fig 1. Note length of incision and wide retraction exposing entire external oblique aponeurosis.

From the Department of Surgery, St. Mary's Hospital, Philadelphia, Pennsylvania.



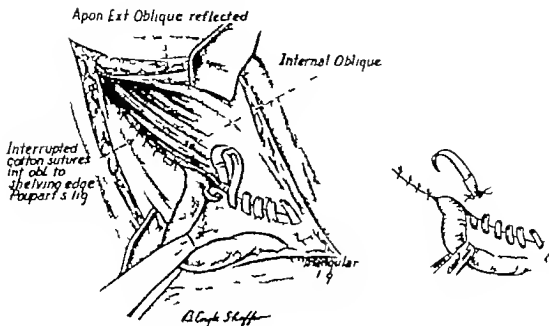


Fig. 4. Inset shows the anchoring of the completed fascial suture below the cord

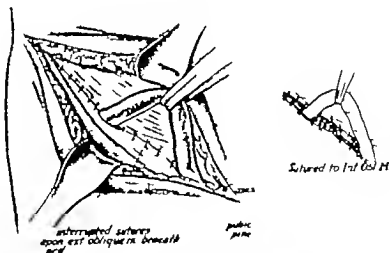


Fig. 5. Completion of the suture when the remaining aponeurosis is not under tension. Inset shows technique of suturing to the internal oblique muscle when the remaining aponeurosis is under tension

The aponeurosis is then split at the upper margin of the external ring, the split being carried upward and outward with scissors, to the point where the aponeurosis merges into the muscle. Both upper and lower leaves are undermined to the fullest extent, and all areolar tissue is dissected from the under surface. The hernial sac is then carefully and sharply dissected from the cord, opened, its contents noted and, if possible, reduced. It is twisted several times on its long axis and tied at its base with two transfixion ligatures, the distal one about 1 centimeter from the proximal one. The ends of the distal ligature are left long. The excess sac is excised, the two ligature ends are threaded on separate needles and carried up beneath and then through the internal oblique muscle where they are tied firmly but not tightly enough to interfere with circulation. The cord is gently freed and retracted with saline moistened tapes. A strip 1 centimeter wide is split from the upper leaf of the external oblique aponeurosis beginning above and continuing down to its attachment to the spine of the pubis. Care must be taken at the upper end to ligate the muscle where the strip ends, else a hematoma will develop. The ligamentum inguinale reflexum (triangular fascia, Colles' fascia), a continuation of the lower part of the shelving edge of Poupart's ligament, is then exposed, the fascial suture is fixed in the Bissard needle, and the first suture is carried over the pubic spine, and a good bite is taken of the ligamentum inguinale reflexum. Care must be taken to prevent twisting of the fascial suture. Then, depending on the conformation present and whether the internal oblique is broad and situated low in the wound, two methods of beginning the closure are carried out: (1) The fascial suture is carried through the shelving edge of Poupart's ligament. (2) The internal oblique muscle is picked up in the suture and then through the shelving edge of Poupart's ligament. By continuous method it approximates the internal oblique muscle and shelving edge of Poupart's ligament, including the cremaster muscle with each loop. This closes the lower angle and narrows and strengthens the inguinal triangle. This fascial suture is carried upward as high as possible to just below where the cord emerges. The fascial suture is then fixed in the belly of the internal oblique muscle by interrupted sutures. Above the cord the closure is completed with interrupted sutures. The remaining part of the upper leaf and all of the lower leaf of the external oblique aponeurosis are approximated by interrupted sutures beneath the cord. This approximation can practically always be done without

tension, but in case there is tension, these two leaves are sutured down to the internal oblique muscle. The skin and fascia are then closed with interrupted sutures and Michel clips.

After operation, the patient is placed in a semirecumbent position with the knees flexed in order to relax the abdominal wall. He is kept in bed for 14 days and leaves the hospital in 16. All sutures are removed on the 7th day, following which he wears an athletic support with a wide abdominal band. On discharge from the hospital he remains in his room or on the same floor, not being permitted to use the stairs for a week. From this time on gradual resumption of walking only is permitted. If his occupation is a sedentary one, he is permitted to return to work in 1 month from the date of operation. If it is a mechanical one which requires no heavy lifting or climbing, he is permitted to return to work in 2 months. If his work is in heavy industry and requires lifting and climbing and other heavy muscular effort, he is permitted to return to work in 3 months. A careful examination, however, is made before he is permitted to return to work and then he is instructed against any sudden starts, twists, and lifts for at least 6 months.

We have carried out this procedure now in 106 inguinal hernias, 12 of which were direct. All were cases covered by workmen's compensation in which operation was agreed to by the employer or the insurance carrier. For that reason we were able to follow 92 of them back to work and to keep in touch with them. The oldest patient was 60 years of age, the youngest was 20, and all but 15 were under 40. If the patient was otherwise in good general condition we operated in all cases regardless of age. Several not in this series were supplied with supports because of poor general condition, regardless of the size or type of the hernia. There were no deaths and no serious wound complications. In 8 cases a sinus developed and discharged a suture and then cleared up. In all cases No. 30 and No. 50 black spool cotton was the only suture material and ligature material which was used except for the Michel clips in the skin.

#### SUMMARY

1. We believe that living fascial sutures used in the simple method described should have further trial in the repair of inguinal hernias.

2. Patients engaged in active physical occupations requiring climbing and lifting should not be permitted to return to work for 3 months after operation.

3. Ninety-two of 106 patients have been followed back to their work, and up to date we have

not been able to demonstrate any recurrences in these 92 patients. The most recent operation in this series was performed 6 months ago.

NOTE.—While we were gradually gathering this group of cases, McCloskey and Lebrun (*Ann Surg* 920, 6) reported series using practically the same procedure.

## REFERENCES

- ANDERSON, E. *Surg. Gyn. Obst.*, 954, 22 753-761.
2. BROADBENT, Dewey J. *Surg. Gyn. Obst.*, 930, 68 3-7.
3. BOLAND, F. K. *South. Surgeon*, 941 05 272-275.
4. BURTON, C. C., and BLONICKA, C. *Surg. Gyn. Obst.*, 94 731 212-217.
5. CARROLL, E. H. *Surg. Gyn. Obst.*, 939, 69 247-252.
6. EATON, W. L. JR. *Am. J. Surg.* 94 31 813-850.
7. FORTNER, G. V. *Surg. Gyn. Obst.*, 936, 63 612-615.
8. HICKS, E. S. *Canad. M. Ass. J.* 94 4 34-35.
9. JAMES, A. H. *Am. J. Surg.*, 935, 27 266-270.
10. JENNINGS, W. K. *Surg. Gyn. Obst.*, 942, 74 607-707.
- LOWMEYER, A. B. *Surg. Gyn. Obst.*, 932, 63 39-46.
2. McNEELY R. W. *Surg. Gyn. Obst.*, 944, 74 12-160.
3. M. CLINTON, S. R. *Minnesota M.*, 938, 21 7.
14. MITCHELL, H. *Med. Rec.*, N. Y., 913 22 207-21.
5. PATTEN, ROBT. LEE. *South. M. J.* 934, 271 20.
6. RAMBO, R. L. and BURROCK C. C. *Surg. Gyn. Obst.* 940, 70 953-957.
7. ROMBERG, C. R. *Ann. Surg.* 932, 95 239-249.
8. TIBBELL, 94 14 8-12.
9. SACKETT, L. *Surg. Gyn. Obst.*, 939, 69 212-217.
20. SWETON, V. W. and SCHWALBE, L. J. *Surg. Clin. N. America*, 935, 5 1621-1651.
- VALL, J. R., and BAKER, D. D. *Surgery* 1938, 31 589-592.
22. WEST, E. T. *South. M. J.* 938, 3 770-772.
23. WILLIAMSON, J. C. F. L. *Brit. J. Surg.* 194 21 334-403.
24. WILLIAMS, C. L. *Surg. Gyn. Obst.*, 940, 7 261-267.
5. ZIMMERMAN, LEO M. *Surg. Gyn. Obst.*, 937 66 102-108.
26. Idem. *Surg. Gyn. Obst.*, *Internat. Abstr. Surg.* 1939, 68 3-30.
7. Idem. *Surg. Gyn. Obst.*, 940, 71 654-663.

# PREGNANCY IN THE MONKEY AFTER REMOVAL OF THE FETUS

G van WAGENEN, Ph D, New Haven, Connecticut

W H NEWTON, D Sc, London, England

PREGNANCY is defined as the condition of the mother after conception and before birth of the child. Generally speaking, the idea of pregnancy assumes the continued presence of a developing embryo. Perhaps this has been so because death of the human fetus usually is followed by spontaneous emptying of the uterus, although this need not be a precipitate event (Streeter). The experiments with monkeys described here bring out the fact that *pregnancy, in terms of the altered maternal physiology, can be independent of the presence of the fetus for the greater part of its length*. Also, during these later months of gestation in the monkey the relative importance of the rôle of the placenta as an organ of internal secretion is emphasized and a second phenomenon, the onset of labor, is shown to be unquestionably independent of the immediate presence of the fetus.

Halban in 1905, from clinical observation alone, fully described the influence of the placenta on both the fetal and the maternal organisms. He pointed out that gravidity changes in the uterus when tubal gestation was present indicated that the placenta effected these changes through the blood stream and therefore was an organ of internal secretion. The term hormone was not yet in use. Halban stated that the source of the substances causing the pregnancy reaction was in the chorionic epithelium and observed that after early abortion of the fetus alone, or when a mole was present, growth of the uterus continued and lactation was held in check.

Since the introduction of hormone assay methods, quantitative evidence of endocrine activity of the isolated placenta has been obtained by Frank (1929) in a case in which the placenta remained in the uterus 18 days following delivery. In a study of an abdominal pregnancy after a term fetus had been removed and while of necessity the placenta had been left attached to the

viscera, Ware and Main (1934) showed that the patient remained physiologically pregnant for over a month following removal of the baby. At the end of that time the urine assays became negative and the placenta presumably had degenerated.

The first experimental work in which fetoplacental dissociation was accomplished was mainly concerned with growth of the mammary gland and lactation. Using the rabbit Weymeersch (1912) demonstrated that placentae persisted for some time in the uterus after the embryos were removed, and Hammond (8, 16) in 1914, observed that once started, placentae of rabbit fetuses which had atrophied at an early stage during development, persisted in some cases during the whole course of gestation. Although much smaller in size they were found toward the end of gestation attached to the uterine wall between the sites of implantations of living fetuses. The rabbit in spite of these early observations was found to be an unfavorable animal in which to study placental retention after experimental destruction of fetuses. It has been noted by Hammond and many times experienced in our laboratory (16) that in rabbits which had been subjected to operation, isolated placentae soon became detached from the wall and were expelled or later found in the uterine cavity during which time the signs of pregnancy diminished at irregular intervals after operation.

In the mouse the rôle of the placenta has been extensively studied (Newton, 1, 12, 13). In this animal the placenta survives destruction of that part of the developing ovum representing the future individual, and mice with retained placentae may, therefore, be used for comparison with those in which the uteri have been completely evacuated in the course of pregnancy. Such comparison shows that several of the maternal phenomena associated with pregnancy are determined by the presence of placentae. Thus estrus is suppressed, though it follows immediately upon total removal of the products of conception, body weight is maintained instead of abruptly falling and full mammary development

From the Department of Obstetrics and Gynecology Yale University School of Medicine. This investigation was supported by grants from the John and Mary R. Markle Foundation and the Fluid Research Fund of the Yale University School of Medicine. An abstract of this work appeared in the Am J Physiol 1940 129 485

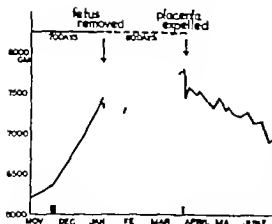


Fig. 1. Monkey C, body weight curve from day of conception through pregnancy and postpartum eight days. The broken line indicates the time after removal of the fetus when only the placenta remained in the uterus.

occurs instead of rapid involution. The os pubis undergoes bony resorption so that the symphysis is replaced by a ligamentous structure as described in normal pregnancy by Gardner. Karch has confirmed these observations on the cat.

Data from the observation of other animals, while not so complete, furnish confirmation that the presence of living placentae in the uterus exerts a marked physiological effect on the maternal organism. Courner and Gros have accomplished growth of independent placental tissue in the cat for 3 weeks, during which time the uterus remained hypertrophied. In the rat, Klein showed that suppression of estrus and the modification of the vaginal wall depended on the placenta without the presence of the fetus. In the rat, also Selver, Collip and Thomson demonstrated that the life span of the placenta was not markedly influenced by the removal of embryos and that the mammary glands continued development.

#### EXPERIMENTAL

The following experiments delineate the circumstances of fetoplacental dissociation even more distinctly because the study has been carried out on a primate animal in which the anatomy of the genital tract and the physiology of reproduction are similar to human anatomy and physiology. More particularly this monkey (*Macaca mulatta*) has menstrual cycle of 8 days rather than the estrus cycle and the period of gestation covers six 28-day months (168 days) thus allowing such events as surgical procedures and parturition to be separated by a sufficient

interval of time to establish their independence of each other.

Twelve pregnancies of 11 monkeys, all of which previously had carried babies to term, were included in these experiments. In our colony animals customarily are mated for 48 hours during the midcycle and when pregnancy is determined, day 13 of the day nearest the 13th day of that particular menstrual cycle is counted as the first day of the pregnancy. From these animals fetuses were removed at different times, as early as the 70th day and as late as the 157th day after conception. Data concerning all pregnancies (eleven) in which the placenta was retained in the uterus after the removal of the fetus are presented in Table I. In 1 of the 11 pregnancies the placenta separated from the uterine wall during the operation, and complete evacuation of the uterus became necessary.

For success in the procedure of removing the fetus but leaving the placenta in place one point is apparently important: care must be taken not to cut the edge of the placenta. The operation can be described simply. A midline abdominal incision is made large enough to permit delivery of the uterus, following which palpation of that organ discloses the position of the bidiscoidal placenta. A generous uterine incision is made between the two placental lobes. The fetus is then lifted from the uterus, and the cord doubly ligated and cut. The placental end of the cord is dropped back into the amniotic cavity and the uterine incision closed with a single subperitoneal, continuous suture of catgut. Delays in procedure must be avoided because handling of the uterus and section of the uterine musculature causes uterine contraction which, in the earlier months of gestation, makes the placental position.

In Figure 1 the events modifying the growth curve for monkey C are noted and the time covered is indicated by months. In this animal a male fetus weighing 50 grams was removed on the 70th day of pregnancy following which the placenta remained in the uterus for 80 days. On the 150th day the placenta was spontaneously expelled. This was 17 days before the estimated day of delivery but only 7 days earlier than the time of delivery of a normal baby in the preceding gestation of this animal. In multiparous animal early delivery is not unusual. The drop in weight at time of operation was from 7,450 to 7,235 grams and most of this decrease was accounted for by the weight of the fetus and the loss of blood with amniotic fluid. In this animal, as in most, there was also a further loss of weight during the ensuing week due to dehydration.

TABLE I—DURATION OF PLACENTAL RETENTION IN RELATION TO INTERVAL BEFORE REMOVAL OF FETUS AND TOTAL LENGTH OF PREGNANCY

Monkey pregnancies	Length of pregnancy before fetus was removed	Weight of fetus	Time placenta was retained in uterus	Total number of days before expulsion of placenta
	days	grams	days	days
C	70	30	80	150
D	73*	44	90	163
B	73	50	82	155
F	99	192	70	169
J	99†	135	48	147
K	99†	142	15	114
A	100	128	84	184
E	100*	156	57	157
I	126	302	27	153
H	139	400	15	154
G	157	411	13	170

\*Both ovaries removed  
†Corpus luteum removed

trauma, and interference with feeding habits incident to the anesthetic and abdominohysterotomy

The interesting part of the curve presented here is the resumption of the weight gain ordinarily coincident with pregnancy. The segment showing weight increment during the second half of this pregnancy parallels the pitch of the curve during the early part of pregnancy while the fetus was present. In other words, after recovery from the hysterotomy the fetal animal carried on with the pregnancy not in *status quo*, but with the pregnancy proceeding in respect to weight increment much as it would have under normally pregnant conditions. Other characteristics of the pregnancy habitus were also continued, the sex skin color heightened, and the generalized edema and the physical inactivity of the pregnant monkey together gave the outward appearance of sustained pregnancy.

Labor under these unusual conditions consists of what may be considered only the first and third stages. The signs of impending delivery are not different from usual, the animal walks about the cage, at intervals taking a sitting position on the board with hands and feet gripping the wire immediately in front of her. Strong uterine contractions can be palpated. The animal usually grasps the placenta as it appears in the vaginal orifice and makes an effort to retain and to eat it

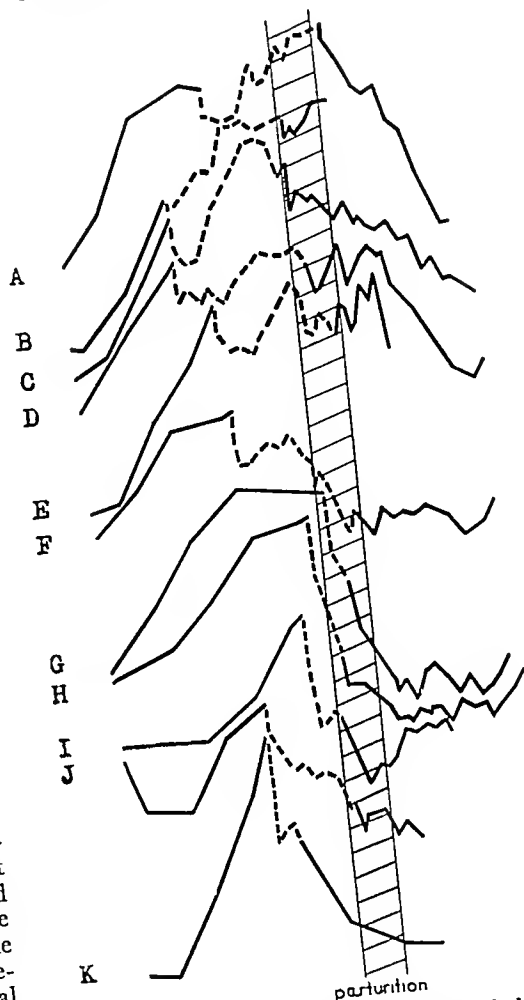


Fig 2 Weight curves of all animals from which the fetus alone was removed during pregnancy. Broken line indicates the period during which the placenta remained in the uterus. Note that in all but the last curve this period extends into the time zone when normal end of pregnancy is expected.

Whether or not the length of labor is shortened in these cases cannot be definitely stated, but our impression is that it is not markedly sluggish or prolonged.

In the weight curve for monkey C the immediate antepartum weight loss is typical of the normal animal and the postpartum weight curve shows the usual descent. The weight taken the day before delivery of the placenta was 7,820 grams and when the animal was weighed at the time she was caught to obtain the placenta it had fallen to 7,440 grams. This drop is, of course,

much less than the usual weight change before and after delivery of a normal sized baby.

On the abacises two periods of vaginal bleeding are shown. The first occurred 21 days after the day of conception, giving a cycle length of 32 days. The conception cycle is slightly longer than the infertile cycles and the bleeding after conception has been called the placental sign (9). A short bleeding in early April followed the separation of the placenta. With the exception of monkey A all the other animals had a longer period of bleeding at the time of placental delivery with a normal lochial discharge.

The main points of the analysis of the growth curve for monkey C are for the most part true for the curves for all the animals which are assembled in Figure 2. In this chart the broken line represents the weight curves during the time after removal of the fetus and before expulsion of the placenta. The latticed column indicates the span of time between the 147th day and 182nd day after conception. Within these limits all the viable babies of our colony have been born. The first six records show the resumption of weight gain after recovery from laparotomy. Monkeys G and H were operated upon so late in gestation, the 157th and 159th days, that antepartum weight loss was probably imposed before recovery from laparotomy. This may be the reason for the similar reaction of monkey I. It will be seen that with one exception (pregnancy K) the broken line of placental retention extends into the zone which indicates an appropriate time for the birth of a living baby.

The length of time the placenta remained *in situ* was in direct ratio to the length of time between fetus removal and estimated parturition. Thus the placenta was retained 80 days and 90 days in instances in which the fetus was removed on the 70th and 73rd days of pregnancy and when the fetus was removed on the 157th day of pregnancy it was expelled 15 days later.

In monkey K the placental lobe lying on the anterior uterine wall was cut into inadvertently and, although complete separation was avoided, it is possible that a retroplacental hematoma formed which accounted for the interruption of pregnancy at 114 days with but 15 days of placental retention. This animal readily became pregnant again and the history of the second pregnancy (D in Table I and Fig. 2) shows removal of fetus at 99 days with retention of the placenta for 70 days and delivery occurring a single day later than the day estimated as the end of pregnancy. This was the only duplication of pregnancy in the series.

In seeking the factors ultimately concerned in the duration of pregnancy and onset of labor it was necessary to check the dispensability of the corpus luteum of gestation and the ovaries in this new situation of fetal absence. In women and in the normally pregnant monkey (9) the corpus luteum is apparently essential only for the implantation and early development of the ovum, while in rats and mice the ovaries are necessary throughout gestation. In our experiments the ovary containing the corpus luteum of gestation was removed at the time the fetus was taken away in the pregnancies J and K, and both ovaries were removed in pregnancies D and E.

In Table I the data concerning pregnancy and operation for the 11 pregnancies are assembled and so arranged that the animal operated upon earliest in gestation appears first. It follows in general that the fetus and placenta increase in size as the fetuses are allowed longer residence *in utero*.

A correlated investigation by one of us (17, 18) has yielded further evidence of a sustained habitus of pregnancy for it was found that the "physiological hydroureter of pregnancy" can be demonstrated by intravenous urography to persist and even to appear after removal of the fetus when the placenta remained *in situ* and functional.

In a second parallel investigation (3) assays of urine of the animals participating in the experiments reported here indicated that the increased excretion of estrogens and androgens characteristic of pregnancy were continued throughout the time of placental retention. Following expulsion of the placenta alone the estrogens immediately decreased to nonpregnant levels, while the high concentration of androgens persisted for a month postpartum as was the case after normal parturition.

#### ANALYSIS OF STUDY

When the umbilical cord is cut and the fetus removed the active circulation of blood through the placenta is abruptly stopped. It is surprising that such a procedure, particularly when it is necessary first to cut through the uterine musculature, is not followed by immediate and effective contraction of the uterus and expulsion of the placenta.

As is demonstrated in the experimental work presented here the monkey without a fetus remains in a condition of physiological pregnancy. Certain facts point to this being something more than a *status quo* such as later resumption of weight increase and the appearance of ureteral

distention in late pregnancy. On the other hand, apparently lactation did not always follow expulsion of the placenta. This point could not be demonstrated with the clarity to be hoped for because the influence of suckling young was absent and because some secretion is continuously present in certain animals when they are bred year after year. Certain it is that simple removal of the fetus does not bring about lactation even when the procedure is carried out in the last month of pregnancy. The fetal surface of the placenta which has been deprived of the fetus is pale and atrophic.

#### SUMMARY

Fetuses have been removed from 11 rhesus monkeys and the placentae left attached to the uterine wall, and functional. The placenta remained in the uterus for the normal duration of pregnancy (defined as a time compatible with the expectation of a viable baby). Onset of labor and delivery of the placenta were normal. The placenta was spontaneously expelled after remaining in the uterus as long as 3 months in the absence of the fetus.

During the time of placental retention the animal remained physiologically pregnant as illustrated by the several lines of evidence here presented. The most striking of these was the fact that the growth curve, after a temporary break due to removal of the weight of fetus and dehydration of operative interference, showed a progressive increase in weight which paralleled the weight-increment value in the first half of pregnancy. The usual postpartum weight loss followed delivery of the placenta.

The animals continued pregnant in appearance because of the intensification of the sex skin color, the continued presence of the generalized edema, and characteristic physical inactivity.

The length of placental retention was in direct ratio to the length of time between fetus removal and estimated end of pregnancy.

The timely onset of labor in these animals was shown to be independent not only of the immediate presence of the fetus, but also of the corpus luteum of gestation and the presence of both ovaries.

Lactation which usually follows emptying of the uterus was held in check as long as the placenta was present, but did not always follow delivery of the placenta.

Two correlated investigations furnished further evidence of physiological pregnancy in these animals. First (18), the hydroureter commonly found in late pregnancy was seen to persist until expulsion of the placenta, when it decreased abruptly. Second (3), urine assays made during the 3 periods into which this study is divided—normal pregnancy, placental retention, and the postpartum period—indicated that the increased excretion of estrogens and androgens characteristic of pregnancy were continued throughout the time of placental retention after which the usual postpartum drop of the estrogens to nonpregnant levels occurred. The androgens, as was found to be the case in the normal animal, decreased after the postpartum month of adrenal adjustment.

#### REFERENCES

- 1 BROOKSBY, J. B., and NEWTON, W. H. *J. Physiol.*, 1938, 92, 136.
- 2 COURRIER, R., and GROS, G. *C. rend. Soc. biol.*, 1936, 121, 1517.
- 3 DORFMAN, R. I., and VAN WAGENEN, G. *Surg. Gyn. Obst.*, 1941, 73, 545.
- 4 FRANK, R. T. *The Female Sex Hormone*. Springfield, Illinois: Charles C. Thomas, 1929.
- 5 GARDNER, W. U. *Am. J. Anat.*, 1936, 59, 459.
- 6 HALBAN, J. *Arch. Gyn. Berl.*, 1905, 75, 353.
- 7 HAMMOND, J. *J. Agr. Sc.*, 1914, 6, 263.
- 8 Idem. *Proc. R. Soc. Lond.*, 1917, 89, ser. B, 534.
- 9 HARTMAN, C. G. *Contrib. Embryol.* (No. 134). Carnegie Inst., 1932, 13, 1.
- 10 KIRSCH, R. E. *Am. J. Physiol.*, 1938, 122, 86.
- 11 KLEIN, M. *C. rend. Soc. biol.*, 1938, 127, 1298.
- 12 NEWTON, W. H. *J. Physiol. Lond.*, 1935, 84, 196.
- 13 NEWTON, W. H., and LITS, I. *J. Anat. Rec.*, 1938, 72, 333.
- 14 SELYE, H., COLLIP, J. B., and THOMSON, D. L. *Endocrinology*, 1935, 19, 151.
- 15 STREETER, G. *Contrib. Embryol.*, 1930, 1, 44.
- 16 VAN WAGENEN, G., and CATCHPOLE, H. R. Unpublished observations.
- 17 VAN WAGENEN, G., and JENKINS, R. H. *J. Urol.*, 1939, 42, 1010.
- 18 Ibid., 1943, 49, 228.
- 19 VAN WAGENEN, G., and NEWTON, W. H. *Am. J. Physiol.*, 1940, 129, 485.
- 20 WARE, H. H., and MAIN, R. J. *Am. J. Obst.*, 1934, 27, 756.
- 21 WEYMEERSCH, A. *Ann. Soc. sc. méd. natur., Bruxelles*, 1912, 70, 104.



# PYOGENIC SEPSIS

## A Survey of 255 Cases

HAROLD NEUKOF M.D., F.A.C.S. and ARTHUR H. AUFSES M.D. F.A.C.S.,  
New York, New York

IN 1934 an analysis was made of 150 cases of septicemia due to pyogenic bacteria. Its purpose was to elicit data which would aid in earlier diagnosis and which would suggest therapeutic procedures that might bring about a reduction in mortality. The study revealed that too much emphasis was placed on blood cultures and too little upon clinical criteria. It also pointed out various questionable aspects of some rather generally held beliefs. In addition evidence was advanced to show that suppurative phlebitis of a substantial vein was a not uncommon cause of pyogenic sepsis. Furthermore the lesion was frequently situated in accessible venous trunks, and its surgical eradication, when feasible was advocated.

Pyogenic sepsis appears to have received no extended attention in the intervening years, and interest in the subject today appears to be based chiefly on the results obtained by chemotherapy. Although this great advance in the treatment of septicemia, which has reduced the death rate appreciably now overshadows other considerations, the mortality is still high. Hence it is important to learn what advances can be made in other directions. A particular reason for re-evaluating the subject at the present time is that septicemia is the most important complication of infected war wounds, especially of the extremities. In order to relate the results of chemotherapy to the problem as well as to compare the problem of pyogenic sepsis today with that of a decade ago the cases at Mt. Sinai Hospital since 1934 are analyzed herein and are compared with the original series.

By pyogenic septicemia or sepsis is meant a clinically recognizable septic state in which an organism (usually pyogenic) can be cultured from the blood stream. The records from January 1934, to December 31, 1942 were examined. All cases with positive blood culture were scrutinized and 255 satisfactorily documented cases were found. In all, a collection of pus or a phlegmonous infection was found in one or more tissues of

the body. The original suppurative focus usually produced clinical manifestations but in a few instances it was found only at postmortem examination.

On the basis of the foregoing definition of pyogenic sepsis, there were excluded cases of transient bacteremia without abscess formation occurring during genitourinary infections or following surgical procedures on the urinary tract, and cases of cholangitis and of enteritis (in infancy). Pharyngeal infections with positive blood cultures were excluded unless there was purulent collection in the pharynx, in the adjacent cervical nodes, or in a more distant (metastatic) focus. Terminal bacteremias were not included even in the presence of a suppurative foci. Suppurative pyelophlebitis is characterized by the clinical picture of septicemia but, for uniformity all cases of infection draining into the portal system have been excluded unless attended by positive blood culture. Diseases in which non-pyogenic bacteremia exists, such as subacute bacterial endocarditis, typhoid fever and pneumococemia (without pus formation) were also omitted.

More than one positive blood culture was obtained in most of the cases in this series. The absence of a subsequent positive blood culture in the balance of the cases was usually due to the rapid effect of adequate therapy. The cases in this latter small group all presented the clinical manifestations of septicemia. Thus the absence of additional positive cultures did not mean that there had existed a transient bacteremia without clinical significance.

In the study of the records for cases of pyogenic sepsis (with positive blood cultures) cases of clinical septicemia with negative blood cultures were also included. A few cases were found but often the negative findings were based either on too few blood cultures or on inadequate amounts of blood obtained for culture. These cases have been excluded because they are too few in number for analysis, and their inclusion in this study would not have influenced in any material way the statistical data which is to be set forth.

From the Clinical Service and the Department of Laboratory, The Mt. Sinai Hospital, New York.  
Contributed to the Symposium on Surgical Infection, 1944, p. 226.

# NEUHOF, AUFSES PYOGENIC SEPSIS

TABLE I — ORIGIN OF SEPSIS

	No. cases	Incidence per cent	Incidence 1934 series per cent
Otitis, mastoiditis, lateral sinus or jugular bulb phlebitis	55	21	19
Subcutaneous abscesses, carbuncles, cellulitis	49	19	19
Osteomyelitis, suppurative arthritis	35	14	24
Postoperative	24	9	7
Genitourinary	17	7	1
Paranasal sinuses	16	6	7
Liver and gall bladder	11	4	
Miscellaneous	9		
Traumatic	6		
Pharyngitis, tonsillitis	6		
Appendiceal abscess			
Postpartum and postabortion	6		
Lung abscess	6		
Peritonitis	5		
Traumatic phlebitis (intravenous medication)	5		
Undetermined	4		
Pneumonia	1		19
Total	255		

TABLE II — MORTALITY IN RELATION TO CHILLS

	No cases	Mortality per cent	Mortality 1934 series per cent
No chills	125	47	62
One chill	22	59	77
Two or three chills	43	58	70
More than three chills	65	64	68
Combined mortality of cases with chills		61	72

TABLE III — CHILLS — THEIR INCIDENCE IN RELATION TO THE ORIGIN OF SEPSIS

	Incidence per cent	Incidence 1934 series per cent
Occurred in 130 cases	51	46
Otitis, mastoiditis etc	47	55
Abscesses, carbuncles, cellulitis	59	32
Osteomyelitis, suppurative arthritis	40	33
Postoperative	50	45
Paranasal sinuses	44	
Genitourinary	76	
Liver and gall bladder	82	90
Miscellaneous	43	43
Cases with acute endocarditis	60	43
Cases with proved phlebitis (excluding lateral sinus)	65	63

In the analysis of the cases in this series, the classifications used in the original series of 150 cases are employed whenever possible. This permits a precise comparison of the two series. Wherever the tables are comparable, the figures from the first group of cases are added.

*Yearly distribution of cases (Table XV)* With the exception of the 2 years 1935 and 1936, the number of cases yearly ranged between 35 and 45 up to 1940, when a decline began which reached a low of 11 cases in 1942. This marked decrease in the last 2 years is probably due to the widespread use of the sulfonamides in pre-septicemic conditions.

*Origin of sepsis (Table I)* At times an arbitrary classification of the cases in respect to the focus from which the bacteria found entrance into the blood stream appeared warranted. For instance, of the 35 cases listed under osteomyelitis and suppurative arthritis, at least 10 had had a previous history of a boil or furuncle comprising the probable primary portal of entry. However, the clinical manifestation at the time of the septicemia being referable to the osseous or articular focus, the cases were placed in that group. Similarly a number of cases in the genitourinary group comprised renal and perirenal abscesses which presumably were derived, via the blood stream, from a superficial focus of infection.

In the miscellaneous group, cases listed under pharyngitis and tonsillitis as the point of origin were those in which the throat infection played a

distinct and significant part in the onset of the septicemia. Among the cases listed as peritonitis, there was some other portal of entry but the peritoneal infection was the outstanding feature in the clinical picture. Although there was usually an associated infection of paranasal sinuses and adjacent bones, such instances were not included in the osteomyelitis group, which was limited almost entirely to the long bones and vertebrae. The 4 cases in which the origin of the sepsis could not be determined clinically were all carefully examined at postmortem examination, but the primary focus could not be discovered.

More than one-half of all the cases fall in the three largest groups: mastoiditis, abscess or carbuncle, and osteomyelitis. The only significant variations from the first series are a decrease in the relative number of cases of osteomyelitis and an increase in cases of infection of paranasal sinuses and of the genitourinary tract.

*Chills (Tables II and III)* The results of the study of the present series are essentially the same as regards chills as are those of the first series. Despite a widely held impression, chills do not occur in the great majority of the cases of sepsis. They were present in only half of all cases. Furthermore neither the presence nor the absence of chills appears to constitute a significant factor in prognosis. The mortality rate was 47 per cent in cases without chills and 61 per cent in the presence of chills. As can be seen in Table III, the relative

TABLE IV.—MORTALITY IN RELATION TO TYPE OF FEVER

	Low	Type of fever Elevated	Spiking
No. cases	9	73	63
Incidence—per cent.	7	29	64
Incidence 1934 series—per cent	3	30	44
Mortality—per cent	33	70	47
Mortality 1934 series—per cent	5	76	63

\*Twenty-one cases in the 1934 series were classified as having an irregular temperature curve.

incidence of chills, not only in the entire series but also in the individual groups, runs parallel to the 1934 series. The somewhat lower mortality of the present series (Table II) is to be regarded as the general lowered mortality in this series as compared with the earlier one. (The present mortality rate is 54.5% as compared with the previous one of 67%.)

The only marked differences between the two series in Table III the increased incidence of chills in the abscess-carbuncle group and in cases of proved acute vegetative endocarditis.

TABLE V.—BACTERIA CAUSING SEPSIS AND THEIR INCIDENCE

	No. cases	Incidence per cent	Incidence 1934 series per cent
Staphylococcus aureus	23	36.5	34
Streptococcus hemolyticus	22	36	43
Bacillus coli	5	6	3
Pneumococcus I			
Pneumococcus III	6		
Pneumococcus V			
Pneumococcus VI B			
Pneumococcus VII			
Pneumococcus XXI			
Pneumococcus XXIII			
Pneumococcus total	4	5.5	
Anaerobic streptococcus	0	3.5	3
Bacillus Friedländer	0	3	
Streptococcus subhyaliscus	0	3	7
Staphylococcus albus	4	5	
Bacillus proteus			
Bacillus pyocyaneus			
Streptococcus and staphylococcus			
Enterococcus			
Salmonella enteritidis			
Streptococcus parvulus and staphylococcus			
Pestis canis			
Corynebacterium xerosis			
Bacillus Friedländer and Bacillus coli			
Staphylococcus and enterococcus			
Bacillus fragilis			
Bacillus coli and enterococcus			
Total	55		

TABLE VI.—RELATION OF TYPE OF ORGANISM TO TYPE OF LESION

	No. cases	Incidence per cent	Incidence 1934 series per cent
Otitis, mastoiditis, etc.	53		
Streptococcus hemolyticus	47	85	86
Pneumococcus	4	7	7
Staphylococcus aureus	3	5	
Bacillus Friedländer			
Anaerobic streptococcus			3.3
Abscesses, carbuncles, cellulitis	49		
Staphylococcus aureus	28	57	60
Streptococcus hemolyticus	6	33	21
Anaerobic streptococcus	4		
Streptococcus subhyaliscus	4	4	4
Streptococcus parvulus and staphylococcus			
Osteomyelitis, suppurative arthritis	35		
Staphylococcus aureus	3	84	73
Streptococcus hemolyticus	6		29
Streptococcus and staphylococcus	4		
Postoperative	34		
Streptococcus hemolyticus	6	3	63
Staphylococcus aureus	6	3	
Staphylococcus albus	4	7	
Bacillus coli	3		
Streptococcus subhyaliscus		4	19
Bacillus proteus		4	
Pneumococcus		4	
Salmonella enteritidis		4	
Bacillus fragilis		4	
Paranasal sinuses	4		
Staphylococcus aureus	7	44	
Streptococcus hemolyticus	3	9	
Pneumococcus	3	9	
Anaerobic streptococcus			
Corynebacterium xerosis		6	
Genitourinary	—		
Staphylococcus aureus	8	47	
Bacillus coli		3	
Bacillus pyocyaneus			
Bacillus Friedländer		6	
Lactococcus		6	
Bacillus coli and enterococcus		6	
Liver and gall bladder	—		
Bacillus coli	5	45	50
Bacillus Friedländer	3	27	3
Staphylococcus aureus		9	
Anaerobic streptococcus		9	
Bacillus Friedländer and Bacillus coli		9	

Fever (Table IV) In the first series, only 44 per cent of the cases had typical septic (spiking) temperature curves. In the present group, 64 per cent



TABLE VI.—NATURE OF LESION IN WHICH COMPLICATING ACUTE ENDOCARDITIS OCCURRED

	No. cases (Total 22)	No. cases 1934 series (Total 11)
Otitis, mastoiditis, etc.	3	
Abcesses, carbuncles, cellulitis	5	
Osteomyelitis, suppurative arthritis		
Prosternitis	1	
Lung abscess		
Paranasal sinuses		
Traumatic phlebitis		
Undetermined		

basis for making a prognosis. This corresponds to the conclusion which was reached in the first series.

*Mortality in relation to age (Table V).* Approximately 50 per cent of the patients were in the first two decades of life. This parallels the 1934 series. However a comparison of the two series reveals a marked reduction in the mortality in the first decade and an appreciable increase between the ages of 10 and 19 years. Since there is a high percentage of cases of streptococcal sepsis in the first decade, the lowered mortality may be referable to effective chemotherapy. (Fifty-nine per cent of the cases in the first decade were due to the *Streptococcus hemolyticus* while for the entire series this organism accounted for only 36%.)

*Acute endocarditis.* The analysis of the cases encountered in the first series revealed that the clinical diagnosis of acute endocarditis developing during sepsis was frequently erroneous and the conclusion was reached that the mere assumption of the existence of endocarditis should not interfere with feasible attempts at eradication of the primary or feeding focus.

Analysis of the cases in the present series substantiates the views which were then expressed. There were 14 cases complicated by acute endocarditis which were proved by postmortem examination. The presence of acute endocarditis was suspected clinically in only 7 of the 14 cases. Indeed, in 3 of the cases, clinical notes were made within 24 hours of death, stating that endocarditis was not present.

In 7 cases acute endocarditis was suspected clinically because of the presence of cardiac murmurs, petechiae or both. Three of these 7 cases came to postmortem examination and an endocarditis was not disclosed in any. Thus, the clinical diagnosis of acute endocarditis was incorrect in at least one-half of the cases in which it was made, and the lesion was only suspected in 50 per cent of the cases in which autopsy proved its presence.

TABLE VII.—BACTERIA IN SEPTICEMIA WITH PROVED PHLEBITIS—EXCLUDING LATERAL SINUS

	No. cases 1934 series	No. cases 1934 series
<i>Staphylococcus aureus</i>	17	8
<i>Streptococcus hemolyticus</i>	9	10
<i>Bacillus Friedlander</i>	3	
<i>Bacillus coli</i>	3	1
<i>Streptococcus anhemolyticus</i>	4	7
Anaerobic streptococcus		
<i>Enterococcus</i>		
<i>Staphylococcus albus</i>		
Other organisms		
Total	39	11

Although acute endocarditis is thought by many to be grafted upon a previously diseased valve an antecedent valvular lesion was found in only 4 of the 14 certified cases. Pericarditis was also present in 4 cases and usually was due to the rupture of a torrocaval bacera. Torsal petechiae were present in 6 of the cases complicated by acute endocarditis, and other skin lesions in 3. Chills were present in 9 (Table III) and the spleen was enlarged in 5.

The organisms causing acute endocarditis were chiefly the *Streptococcus hemolyticus*—5 cases in present series, 6 in 1934 series—and the *Staphylococcus aureus*—4 in present series, 6 in 1934 series—occurring with equal frequency. There was 1 case in each series caused by the streptococcus and staphylococcus 2 in the present series and 1 in 1934 series caused by the pneumococcus 1 each in the present series caused by the *Bacillus proteus* and *Bacillus pestis cauae*. A study of the number of colonies in the blood stream reveals that few colonies were present in about one-half of the cases. Of the 14 cases in each of the present and

1934 series, we found less than 15 colonies in 6 cases of present and 5 cases of 1934 series, 30 to 75 colonies in 3 cases of the present series and there were innumerable colonies in 5 cases of each of the present and the 1934 series. This fact negates a rather widely held view that the presence of acute endocarditis may be postulated on the basis of a progressive increase in the number of colonies in the blood. There appears to be no causative relation between the type of the original lesion and the occurrence of acute endocarditis (Table VI).

*Acute suppurative phlebitis.* In 1934 it was stated that many cases of septicemia are due to the presence of a suppurative phlebitis in a large caliber vein acting as a feeding focus. It was argued that the correct therapeutic approach to this type of lesion was the excision of the involved vein when feasible. Furthermore in the present

TABLE XIII —THE ORGANISMS IN CASES WITH MULTIPLE LUNG ABSCESSSES

	No cases	No cases 1934 series
Staphylococcus aureus	27	20
Streptococcus hemolyticus	2	9
Anaerobic streptococcus	2	3
Pneumococcus III	1	
Staphylococcus and streptococcus	1	
Corynebacterium xerosis	1	
Staphylococcus albus	1	1
Other organisms	1	8
Total	36	41

of evidence of a phlebitis of an accessible vein, there is no rationale in waiting for a positive blood culture. We believed that the suppurative process should be drained and the vein bearing the phlebotic area excised. This method of surgical therapy appears to have prevented the development of septicemia in a number of cases in our experience. Excluding intracranial lesions—lateral sinus phlebitis and osteomyelitis of the cranial bones—there were 39 cases of phlebitis proved by operation or postmortem examination. The veins involved were of the extremities, 11, portal system, 9, cervical, 6, renal, 4, cavernous sinus, 4, pulmonary, 2, and 1 each inferior vena cava, umbilical and prostatic.

The bacteria which were found in these cases with demonstrable phlebitis are shown in Table XII. Aside from a reversal in the ratio between the *Streptococcus hemolyticus* and the *Staphylococcus aureus*, they parallel the 1934 findings. As already indicated, the reduction in number of cases due to the *Streptococcus hemolyticus* may be due to the use of chemotherapy.

From the number of colonies found in blood cultures in cases with proved suppurative phlebitis, it is established that phlebitis may occur without massive blood stream invasion. In the present series of 39 cases and the 33 cases in the 1934 series, 1 to 15 colonies were found in 12 of the present and 11 of the 1934 series, 16 to 100 colonies in 6 of the present series, 101 to 500 in 5 of the present, 9 of the 1934 series, and innumerable colonies in 2 of the present series. Data not available in 14 of the present and 13 of the 1934 series.

Chills occurred in 65 per cent of cases with proved phlebitis (Table III). They were present in a smaller percentage (50%) of cases of lateral sinus phlebitis.

A surgical attempt to remove the involved vein was made in 13 cases. Four of these patients survived. Their recovery can be ascribed to the operative procedure. The results undoubtedly

TABLE XIV —MORTALITY IN RELATION TO NUMBER OF PERIPHERAL METASTATIC FOCI

	No cases	Mortality per cent	No cases 1934 series	Mortality per cent
One focus	28	46	31	61
Two foci	7	71	16	75
Three foci	9	44	9	77
Four or more foci	8	37	8	25

would have been better if operations for eradication of the phlebotic focus had been performed before the clinical picture of sepsis was fully established.

*Peripheral metastatic foci.* Metastatic foci occurring during the course of septicemia may be found in any region which is fed by the blood stream. Internally the common seats for embolic abscesses were the lungs, kidneys, and spleen. Peripheral lesions usually manifested themselves as joint infections, subcutaneous or muscle abscesses, and skin foci.

As was previously noted, the mortality was slightly lower in patients with, than in those without, peripheral metastatic foci (48% as compared with 56%). It also appears that the mortality is in inverse proportion to the number of such foci (Table XIV). In this series 52 patients (20%) presented peripheral foci, only some of which were suppurative. This contrasts with the earlier series in which 43 per cent of the patients developed peripheral foci, and probably is ascribable to chemotherapy. Only 14 per cent of the patients receiving chemotherapy developed peripheral foci whereas 25 per cent of patients not treated by chemotherapy had superficial embolic lesions.

It appears to be generally held that the staphylococcus, as compared with the streptococcus, is a much more frequent causative organism in metastatic foci. That this impression is not correct is shown in both series of cases. *Streptococcus hemolyticus*, 26 cases in present, 30 in 1934 series, *Staphylococcus aureus*, 22 cases in this, 25 in 1934 series, other organisms, 4 in this and 9 in 1934 series. Indeed, the streptococcus was found somewhat more frequently in both series as shown. In contradistinction, the staphylococcus predominates as the organism in cases with metastatic pulmonary abscesses (XIII).

*Multiple pulmonary abscesses.* In 36 cases in this series multiple pulmonary abscesses were found at autopsy. There were also 2 instances in which multiple abscesses of the lung were diagnosed roentgenologically and the patients recovered. The incidence of pulmonary abscesses in this series is half of that of the first series.

It is interesting to note that 33 per cent of the 36 cases had less than 25 colonies in the blood

TABLE VI.—CASES RECEIVING CHEMOTHERAPY

Year	Total No. Cases	No. receiving chemotherapy	Per cent
1934	56		
1935	30		
1936	5		
1937	36	9	5
1938	43		30
1939	35	30	37
1940	27		8
1941	9	7	90
1942			100

stream (12 cases in present series, 7 in 1934 series, 15 to 100 colonies in 6 of present and 4 of 1934 series, over 100 colonies in 12 of present and 14 of 1934 series. The number of colonies was unstated in 6 of the present and 17 of the 1934 series.) As has been previously mentioned 75 per cent were caused by the *Staphylococcus aureus* (Table VII). In addition to the cases of multiple lung abscesses, there were 8 cases of solitary lung abscess occurring during the course of the sepsis. Multiple pulmonary abscesses occurring during the course of sepsis are not amenable to surgical therapy. Embolic abscesses have a tendency to perforate into the pleural cavity and this complication must be watched for and treated surgically.

Of special import is the fact that the solitary metastatic lung abscess is amenable to surgery. The fate of the 8 cases in this series is of considerable interest. Four perforated into the pleural cavity causing empyema. In 3 which were drained, the patients recovered. Drainage was also instituted in the 4th case but the patient succumbed to septicemia. In 2 cases, a diagnosis of lung abscess was definitely made on x-ray evidence of an infiltration which in later films showed an area of rarefaction and a fluid level. One of these abscesses subsided spontaneously and the patient was discharged as cured. The other patient was not operated upon and died of septicemia. In the 7th case, a child 13 months, the x-ray film was characteristic of pulmonary abscess. Some time later a tension pneumothorax appeared on the same side without the develop-

TABLE VII.—PERCENTAGE OF VARIOUS GROUPS TREATED WITH CHEMOTHERAPY

	No. Cases	Received chemotherapy	Per cent
Otitis, mastoiditis, etc.	53	44	44
Abscesses, carbuncles, cellulitis	40	37	35
Osteomyelitis, suppurative arthritis	35		34
Postoperative	24	9	37
Paranasal abscess	6	7	44
Genitourinary	7	6	35
Liver and gall bladder		3	27

TABLE VIII.—EFFECT OF SULFAXILAMIDE IN VARIOUS SEPTICEMIAS

Organism	No. Cases	Deaths	Mortality per cent
<i>Streptococcus hemolyticus</i>	30	4	13
<i>Staphylococcus aureus</i>	7	3	43
<i>Bacillus coli</i>	5		00
Anaerobic streptococcus	3		
<i>Bacillus Friedlander</i>			100
<i>Bacillus proteus</i>			
<i>Staphylococcus aureus</i> and paravittis			100
<i>Streptococcus anhemolyticus</i>			100
<i>Staphylococcus aureus</i> and enterococcus			100
Total	5	14	77

ment of an empyema. Following the absorption of the air from the pneumothorax, and the re-expansion of the lung the cavity was no longer visible. In the 8th case a solitary lung abscess, unsuspected clinically, was found at postmortem examination.

It is interesting to note that in 2 of the cases of solitary lung abscess with perforation and empyema, the pulmonary symptoms were the first manifestation of septicemia. Following drainage of the empyema, the septic picture continued and numerous peripheral metastatic foci appeared. It was ultimately discovered that the original focus for the blood stream infection was a phlebitis of the lateral sinus. Operation on the sinus resulted in cure.

The question as to whether the lungs act as filters for the organisms in the blood stream cannot be answered by the study of our cases. Analysis of the cases with multiple lung abscesses, peripheral metastatic foci, and acute endocarditis appears to be of little value. Of 36 patients with pulmonary lesions and 14 patients with acute endocarditis, only 4 had a pathological lesion at both sites. Of the patients with pulmonary abscesses, all but 9 had other internal or peripheral metastatic foci.

The preponderance of the *Staphylococcus aureus* as the causative organism in multiple lung lesions is apparently the only factor which may aid in explaining the presence of multiple pulmonary foci in some cases and their absence in others. In 38 patients with *Staphylococcus aureus* sepsis in whom the lungs were examined at autopsy multiple pulmonary abscesses were found 27 times (71%). In 17 postmortem examinations on *Streptococcus hemolyticus* cases, multiple abscesses of the lungs were found only twice (12%). On the other hand, both organisms were found with almost the same frequency in cases with peripheral metastatic foci and acute endocarditis.

TABLE XVIII — EFFECT OF SULFAPYRIDINE IN VARIOUS SEPTICEMIAS

Organism	No cases	Deaths	Mortality per cent
Staphylococcus aureus	9	4	44
Streptococcus hemolyticus	1	1	100
Bacillus Friedlaender	1	1	100
Pneumococcus I	1	0	
Pneumococcus II	2	2	100
Pneumococcus III	1	1	100
Total	15	9	60

The contrasting behavior of the streptococcus and the staphylococcus in the lungs may be referable to a difference in predilection or in tissue immunity or may be on a mechanical basis. Concerning the latter, it is conceivable that the clumps in the blood stream derived from the feeding focus (vein) may be substantially larger in staphylococci than in streptococcal infections and thus are more easily arrested in the lungs.

*The rôle of chemotherapy.* One hundred patients in this series received chemotherapy in doses considered adequate by present day standards. A number of others received doses too small to be regarded as treated with the sulfonamides. Chemotherapy was started in 1937. Table XV shows the percentage of patients receiving chemotherapy in each year. From 25 per cent in 1937, it reached 100 per cent in 1942.

Sulfanilamide was the drug most commonly used—51 cases. Sulfapyridine was administered in 15 patients and sulfathiazole in 12. Various combinations of the sulfonamides were employed in the 22 remaining cases as follows: sulfanilamide plus sulfapyridine, 5 cases, sulfathiazole plus sulfanilamide, 5 cases, sulfathiazole plus sulfadiazene, 3 cases, sulfathiazole plus sulfapyridine, 2 cases, sulfadiazene, 2 cases, sulfanilamide plus sulfapyridine plus sulfathiazole, 2 cases, and 1 each of the following, sulfanilamide plus sulfadiazene, sulfanilamide plus sulfathiazole plus sulfadiazene, sulfanilamide plus sulfapyridine plus sulfathiazole plus sulfadiazene. Sulfanilamide was used as the sole chemotherapeutic agent in 51

TABLE XIX — EFFECT OF SULFATHIAZOLE IN VARIOUS SEPTICEMIAS

Organism	No cases	Deaths	Mortality per cent
Staphylococcus aureus	9	4	44
Streptococcus hemolyticus	1	1	100
Bacillus Friedlaender	1	1	100
Pneumococcus I	1	0	
Pneumococcus II	2	2	100
Pneumococcus III	1	1	100
Total	15	9	60

TABLE XX — MORTALITY IN CASES TREATED BY COMBINATIONS OF VARIOUS SULFONAMIDES

Organism	No cases	Deaths	Mortality per cent
Staphylococcus aureus	12	4	33
Streptococcus hemolyticus	5	2	40
Streptococcus anhemolyticus	2	1	50
Enterococcus	1	1	100
Bacillus coli and enterococcus	1	1	100
Bacillus fragilis	1	1	100
Total	22	10	45

cases, which is the only group sufficiently large to use as an evaluation of therapeutic effect.

The mortality in the 255 cases was 54.5 per cent. In the 100 patients receiving chemotherapy, the mortality was 38 per cent. In the 155 patients who did not receive the benefit of chemotherapy, the mortality was 65 per cent. This mortality is practically the same as in the series of 150 cases reported in 1934 (67%). It is apparent that the reduction in mortality is due almost entirely to the use of chemotherapy.

Table XVI shows the percentage of the various types of cases treated by chemotherapy. It can be seen that about the same percentage of cases in all groups received the sulfonamide drugs. The slightly higher percentage in the mastoid and paranasal sinus groups is undoubtedly due to the more frequent indication for chemotherapy because of the prevalence of the *Streptococcus hemolyticus* in these infections. (The great majority of the cases treated by chemotherapy occurred before the introduction of sulfathiazole and sulfadiazene.)

Fifty-one patients received sulfanilamide alone. The results of sulfanilamide therapy upon the

TABLE XXI — EFFECT OF CHEMOTHERAPY IN VARIOUS GROUPS

	No cases	Mortality per cent
Otitis, mastoiditis, etc.	55	
Without chemotherapy	31	42
With chemotherapy	24	12.5
Abscesses, carbuncles, cellulitis	49	
Without chemotherapy	32	69
With chemotherapy	17	41
Osteomyelitis, suppurative arthritis	35	
Without chemotherapy	23	69
With chemotherapy	12	33
Otitis, mastoiditis, etc., due to streptococcus hemolyticus	47	
Without chemotherapy	24	33
With chemotherapy	23	9



various organisms are analyzed in Table XVII. As is to be expected, the best results were obtained when sulfanilamide was used for *Streptococcus hemolyticus septicemia*. The effects of sulfapyridine of sulfathiazole and of various combinations of sulfonamides on the different organisms are given in Tables XVIII, XIX, and XX. Because of the small number of cases in each group it is difficult to evaluate the results. The effect of chemotherapy on the three largest groups of cases is shown in Table XXI. It appears from the analysis that although the effect of chemotherapy (in this series) is by far greatest in *Streptococcus hemolyticus sepsis*, it nevertheless has some effect upon other organisms. Thus in the osteomyelitis group of 35 cases, the *Staphylococcus aureus* was the predominating organism, but the mortality in the group in which patients were treated with chemotherapy was 33 per cent as compared with 69 per cent in the cases without chemotherapy. If a single group in which there is a high percentage of *Streptococcus hemolyticus* cases, such as the mastoid group, is examined (Table XXI) it will be noted that in 24 streptococcus cases without chemotherapy there was a mortality of 33 per cent, while in 23 cases with chemotherapy the mortality was 9 per cent.

Examination of the entire series reveals that in no case was an indicated surgical procedure withheld because of the anticipated effect of chemotherapy. Various other therapeutic measures were used in addition to chemotherapy without evidence of definitive effects. One hundred and fifty-five patients received one or more transfusions. *Staphylococcus antitoxin* was administered in 20, *crysipelas antitoxin* in 7 and pneumococcus serum in 6 cases.

#### SUMMARY

A comparison of a series of cases of pyrogenic sepsis (1934-1935) with a similar series (1929-1934) reveals that chemotherapy comprises the most important advance in therapy. Furthermore the widespread use of the sulfonamides has

apparently diminished the incidence of septicemia. However the surgical eradication of the feeding suppurative focus, when feasible, is imperative if the still existent high mortality is to be reduced. This applies particularly to a suppurative phlebitis in a surgically accessible vein. The clinical recognition and eradication of suppurative phlebitis before the advent of confirmed sepsis offers the best outlook for cure.

Analysis of the present series of cases has confirmed the conclusions drawn from the first series, many of which were and still are at variance with some generally held beliefs. They are

- 1 Chills occur in only half the cases of pyrogenic sepsis.

- 2 Chills are single or few in number in more than half of the cases in which they occur.

- 3 The mortality is not appreciably lower in the absence of chills.

- 4 The temperature is of the spiking type in only slightly more than 50 per cent of the cases.

- 5 The number of colonies in the blood culture can not be used as a basis for prognosis.

- 6 The correct diagnosis of acute endocarditis can seldom be made; the lesion does not necessarily develop at the site of previous disease; it may be present with relatively few colonies in the blood culture and chills, petechiae, and postales do not always characterize its course.

- 7 Peripheral metastatic foci are more common in streptococcus than in staphylococcus sepsis.

Chemotherapy in conjunction with surgery directed toward the eradication of the suppurative focus is the best means for combating pyrogenic septicemia. Emphasis should be placed on the necessity for appropriate surgery on a feeding suppurative focus (especially suppurative phlebitis of a venous trunk) or a metastatic focus (such as a solitary abscess of the lung) in order to reduce not only mortality but also morbidity. Suppurative phlebitis can be anticipated as the most common cause of pyrogenic septicemia derived from infected war wounds of the neck and extremities.

# MANUAL REMOVAL OF THE PLACENTA

L D ODELL, M D, and W F HOVIS, M D, Iowa City, Iowa

**M**ANUAL removal of the placenta has long been considered a serious obstetric operation. In fact, until recently (1), the maternal mortality rate has been reported as high as 13.5 per cent (2).

At the University Hospitals, manual removal of the placenta has been approached with trepidation. However, this view was recently subjected to question after observing the benign clinical course of several patients. The following data were assembled to aid in re-evaluating the risk attending the operation.

In a total of 15,824 deliveries between July 1, 1926, and July 1, 1942, manual removal of the placenta was performed 70 times, an incidence of 0.44 per cent. Two maternal deaths (from hemorrhage) occurred in connection with the procedure (2.8 per cent). According to the standards of the American Committee on Maternal Welfare, 42 per cent of the patients in the series were febrile although only 27 per cent were required to remain in the hospital longer than the accustomed 11 postpartum days. There were 47 liveborn (67 per cent) and 23 stillborn (32 per cent) infants of which 8 were pre-viable (11 per cent).

Two major indications for manual removal of the placenta are commonly accepted, prolongation of the third stage of labor and excessive blood loss. Prolongation of the third stage prompted manual removal of the placenta in 28 patients whose blood loss was less than 600 cubic centimeters. Thirty-four operations were indicated because of excessive blood loss (over 600 cubic centimeters) without reference to duration of placental retention. It is of interest that the subsequent morbidity rate of each group was very similar (41.0 and 44.0 per cent) suggesting that intrauterine invasion rather than excessive blood loss was the principal factor in infection. The two indications are graphically portrayed in Figure 2 where the blood loss is plotted in a frequency diagram.

Abnormalities in previous confinements (28.6 per cent), especially previous manual removal of the placenta (11.4 per cent), and complications of the present pregnancy<sup>1</sup> (28.5 per cent) were fre-

quent. Prolonged labor (8.5 per cent), prolonged second stage of labor (17.4 per cent) and operative delivery (41.4 per cent) were three times more frequent than usual (see Tables I and II).

Treatment of retained placenta (5) in the clinic generally follows these lines. In the absence of bleeding, at least 2 hours are allowed to elapse before manual removal is contemplated. During this time, Credé expression under anesthesia,<sup>2</sup> and injection of the umbilical vein with saline (Mojon-Gabaston technique, 3) are frequently employed. If the rate of bleeding is alarming, or if the blood loss becomes excessive, manual removal is performed. If possible, the operation is accomplished upon a single invasion of the uterus and the placental bed is carefully palpated for remaining secundines before the hand is withdrawn. A hot, intrauterine douche is then employed.

It should be emphasized that it is difficult, because of variations, to define a blood loss at which interference becomes indicated. Six hundred cubic centimeters is widely accepted as the maximum of physiologic bleeding but the accoucheur might be negligent in certain cases if he failed to perform the operation before this limit was reached. Similarly, he might be unduly radical in other patients if he interfered solely on this basis.

In this series, the hot, intrauterine douche has contributed materially to promotion of efficient uterine contraction and thus to adequate hemostasis. Uterine tamponade has been necessary only once. In addition, we believe that the douche mechanically cleanses the uterine cavity of bacteria and blood clot which might act as a culture medium.

Shock from excessive blood loss is the greatest immediate danger and must be vigorously combated by all available means. Transfusion of blood may be life saving and is urgently indicated in patients whose blood loss is excessive. If blood is not available, intravenous infusion of plasma or saline solution may be employed. It should be stressed that acute secondary anemia is best treated by transfusion of blood, preferably before the classic signs of shock develop. Obviously,

<sup>2</sup>It is believed that (1) Proper employment of Credé's maneuver is difficult without anesthetization of the patient. (2) The Credé maneuver properly performed does not cause uterine inversion since our only case of acute puerperal inversion of the uterus among 15,824 deliveries was not associated with Credé expression.

From the Department of Obstetrics and Gynecology, State University of Iowa.

<sup>1</sup>Placenta previa 10, toxemia 6, abruptio placentae 1, intra partum fever 1, cardiac failure 1, carcinoma of the cervix 1.

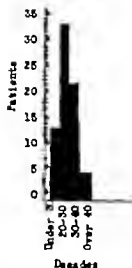


Fig. 1. Age distribution.

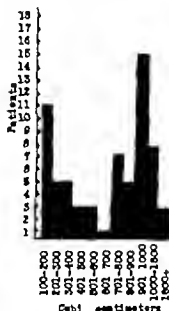


Fig. 2. Note the break at 600 to two cubic centimeters. To the left of the break fall three cases of prolonged third stage of labor (thrust away), blood loss to the neck, excessive hemorrhage. Because of emergency blood loss, measurement is impractical in 4 patients.

oxytocics should be administered to bleeding patients (See Table III).

Serious puerperal infection represents a remote danger to the patient who has recovered from the immediate emergency which may attend manual removal of the placenta, but no patient in our experience died of sepsis. It is our opinion that prophylactic sulfonamide therapy is not justified because of the relatively benign character of the infection. When puerperal sepsis occurred (44.4 per cent) the sulfa drugs were rarely indicated. They were employed only 4 times in 2 patients who had  $\beta$  hemolytic streptococci and in 2 others before culture indications were recognized.

There has been a progressive decrease in mortality rates in the operation of manual removal of the placenta during the past few decades with

a corresponding decrease in the frequency with which it is performed (4). The increasing use of transfusions and oxytocics, as well as more prompt interference have undoubtedly contributed to this result.

TABLE II.—MANUAL REMOVAL OF THE PLACENTA LENGTH OF LABOR AND METHOD OF DELIVERY

	Patients number	Per cent	Average hospital incidence Per cent
Prolonged labor (30 hours or more)		8.5	8
Average labor (three to 30 hours)	57	8.4	85.7
Preceding labor (less than 3 hours)	7	10	5
Prolonged 3d stage (more than 3 hours)		7.4	5
Prolonged 3d stage (more than 30 minutes)	50	74	6.8
Operative labor—total	50	4.4	6
Low forceps		4.2	6
Mid forceps		2.8	6
Breech delivery		8	2.6
Versus and extraction		8.5	7
Cesarean		8	

Note the higher incidence of prolonged labor, prolonged second stage and operative delivery.

TABLE I.—PREVIOUS OBSTETRIC COMPLICATIONS IN PATIENTS WITH MANUAL REMOVAL OF THE PLACENTA

	Patients Number	Per cent
Manual removal of placenta	8	1.4
Spontaneous abortion	3	4
Stillbirth	3	4
Breech		2.8
Placenta previa		8
Puerperal sepsis		2.8
Toxemia		8
Fetotic pregnancy		4
Jamming		1.4
Eclampsia		4
Uncomplicated	50	7.4

Note the high incidence of previous manual removal of the placenta. Five patients had dual complications.

Antecedent hemorrhage or infection greatly increases the danger of manual removal of the placenta. Eastman recommended that manual removal be performed before the blood loss reaches 500 cubic centimeters, while Zangemeister reported a high maternal mortality rate (18 per cent) following the operation in patients with amniotic sac infection. Procrastination during excessive bleeding is probably as radical and hazardous as interference in the presence of intrauterine infection.

The two maternal deaths which occurred in our series are briefly reviewed.

No 40-10112 M C, a 29 year old Mexican, quintipara, nongravida, was admitted to the hospital in July, 1940, with a calculated date of confinement as October 10, 1940. Thirty days after admission she experienced sudden, sharp, lower abdominal pain and a hemorrhage of over 800 cubic centimeters within a few minutes. A transfusion was commenced and vaginal examination revealed placental tissue in the region of the internal os. A No 6 Voorhees' bag was inserted, a 1 pound weight was attached, and pituitrin was administered. The bleeding, however, was not controlled and the condition of the patient became precarious. The bag was removed and re-examination disclosed a dilated cervix but no palpable placental tissue. Internal podalic version was performed without difficulty and a 3,000 gram, stillborn male infant was extracted. The placenta, which was not attached to the uterus, was immediately removed and digital examination revealed no uterine tears. A hot, intrauterine douche failed to control bleeding, and the uterus was packed. Soon after this procedure, the patient expired. No autopsy was granted.

No 41-1559 V C, 25 year old, secundipara, quadri gravida was admitted in February, 1941, with the expected date of confinement February 6, 1941. There was a history of edema and headaches of 2 months' duration. Examination disclosed a blood pressure of 140-100 millimeters of mercury and a trace of albumin. Following premature artificial rupture of the membranes on February 6, 1941, a 26 hour labor terminated spontaneously with the birth of a 2331 gram, living female infant. Following delivery the placenta failed to separate and numerous attempts at Credé expression were made over a 4 hour period together with repeated doses of oxytocics. The rate of bleeding, although never excessive at any time, was continuous. When the blood pressure had fallen to 70/30 millimeters of mercury and an unmeasured amount of blood had been lost, manual removal of the placenta was performed. Transfusions and other restorative measures failed and the patient expired 2 hours after the operation (6 hours after delivery).

Exitus in the first case could hardly be considered the result of manual removal of the pla-

TABLE III—MANUAL REMOVAL OF THE PLACENTA TREATMENT

	Patients	
	Number	Per cent
Oxytocic after 3d stage	57	81.4
Intrauterine douche	49	70.0
Transfusion	33	47.1
Oxytocic before placental delivery	22	31.4
Uterine tamponade	1	1.4

Note the frequent use of intrauterine douche following manual removal. Shock was present in 19 (27.0 per cent) of our series.

centa. The basic condition was fierce and uncontrolled hemorrhage resulting from abruptio placentae and it is extremely doubtful if any therapy could have saved the patient. On the other hand, the second death was a direct result of undue conservatism in the presence of continued blood loss. A fatal result might have been avoided if effective control of hemorrhage, including manual removal of the placenta, had been instituted earlier. In re-evaluating our indications for manual removal, greater emphasis will be placed upon the necessity for the operation when bleeding is continuous and prolonged, even though the rate is not excessive.

#### SUMMARY

The experience at the University Hospitals indicates that

1 Manual removal of the placenta does not carry the risk of infection which is usually assigned to it.

2 Failure to perform the operation in the presence of severe or continuous bleeding, or both, evidently creates a greater risk from hematogenous shock.

#### REFERENCES

- 1 BLOCH, E. *Acta obst. gyn. scand.*, 1937, 17, 343-372.
- 2 EASTMANN, N. J. *Internat. Clin.*, 1939, 3, 264-302.
- 3 MCINTYRE, W. K. *Med. J. Australia*, 1939, 2, 62-68.
- 4 MOLDAVSKY, L. F., and SOLOWAY, L. R. *Am. J. Obst.*, 1941, 42, 434-440.
- 5 SCHUMANN, E. A. *The Pathology of the Third Stage of Labor, with Special Reference to the Placental Element. The Proceedings of the First American Congress on Obstetrics and Gynecology*. Pages 91-96. Evanston, Illinois: Mumm Print Shop, Inc., 1941.
- 6 ZANGEMEISTER, W., and WIELOK, J. *Intrapartale Genitalinfektion, Febris intrapartum*. Halban und Seitz, 1929, 8, 1815-1900.

# EDITORIALS

## SURGERY Gynecology and Obstetrics

FRAKLIN H. MARTIN  
Founder and Managing Editor  
905 1935

---

LOYAL DAVIS, EDITOR

*Associate*

SUMNER L. KOCH      MICH. EL. L. M. 40

---

DONALD C. B. LEITCH, *Associate Editorial Staff*

---

NOVEMBER, 1943

---

### THE SANO METHOD OF ACCELERATED WOUND HEALING

THE older writers on surgery when describing methods of wound healing included union by primary adhesion "a process that to many seemed rare or impossible and now is almost forgotten. Today we discuss wound lag and are impressed by experiments showing that five days or more elapse before the primary union of wounds really begins.

Is such lag in the reparative process essential, or is it possible deliberately to speed the processes of healing? Dr. M. L. Sano of the laboratory for tissue culture at Temple University, Philadelphia, in a preliminary report elsewhere in this issue, suggests the possibility of eliminating wound lag by the use of a cement or binding substance formed of two solutions derived from normal blood. When one is painted on a split or full thickness graft the other upon the area to be grafted, and the two surfaces apposed almost immediate adhe-

sion follows. Oozing of blood is arrested, and the graft is penetrated by vessels so rapidly that it acquires a reddish purple color and the edges may even bleed within 48 hours. In microscopic sections the filled blood vessels of the graft are evident early and it soon is difficult to differentiate the graft from the underlying tissue. The procedure was the outgrowth of observations in the cultivation of embryonic tissue.

A semisolid matrix, such as fibrin, is very important for satisfactory cultivation of the living cells. Dr. Sano noted that the cell growth was tremendously accelerated when a suspension of leucocytes and the other ingredients of the buffy coat from sedimented blood was added to the culture. It seemed probable that the leucocytes have much more than a scavenger action in wound healing.

Observing the tediousness of sewing a full thickness skin graft, while assisting Dr. W. L. Steel, Dr. Sano applied her observations made during tissue culture to experimental skin grafting in November 1941. Full thickness skin grafts were transplanted by adhesion on rats, a suspension of the buffy coat and heparinized plasma being used. The grafts united rapidly and the experiments were successfully repeated on guinea pigs. The hair grew so luxuriantly from the graft that in a few weeks it was difficult to locate the grafted area. In September 1942 she had her first opportunity to use the method in human practice in a grafting by Dr. W. Emory Burnett. The result was impressive and in a recent case of his the patient was walking upon a graft on the heel within a week.

Other observations suggested that epithelialization of the granulating wound about the



# EDITORIALS

## SURGERY Gynecology and Obstetrics

FRANKLIN H. MARTIN  
Founder and Managing Editor  
903 1935

---

LOYAL DAVIS, EDITOR

*Associate*

SUMNER L. KOCH MICH. ED. L. M. 40

---

DOY I. C. BALFOUR *Associate Editorial Staff*

---

NOVEMBER, 1943

---

### THE SANO METHOD OF ACCELERATED WOUND HEALING

THE older writers on surgery when describing methods of wound healing included "union by primary adhesion" a process that to many seemed rare or impossible and now is almost forgotten. Today we discuss wound lag and are impressed by experiments showing that five days or more elapse before the primary union of wounds really begins.

Is such lag in the reparative process essential, or is it possible deliberately to speed the processes of healing? Dr M. E. Sano of the laboratory for tissue culture at Temple University, Philadelphia, in a preliminary report elsewhere in this issue suggests the possibility of eliminating "wound lag" by the use of a cement or binding substance formed of two solutions derived from normal blood. When one is painted on a split or full thickness graft the other upon the area to be grafted, and the two surfaces apposed, almost immediate adhe-

sion follows. Oozing of blood is arrested and the graft is penetrated by vessels so rapidly that it acquires a reddish purple color and the edges may even bleed within 48 hours. In microscopic sections the filled blood vessels of the graft are evident early, and it soon is difficult to differentiate the graft from the underlying tissue. The procedure was the outgrowth of observations in the cultivation of embryonic tissue.

A semisolid matrix, such as fibrin, is very important for satisfactory cultivation of the living cells. Dr Sano noted that the cell growth was tremendously accelerated when a suspension of leucocytes and the other ingredients of the buffy coat from sedimented blood was added to the culture. It seemed probable that the leucocytes have much more than a scavenger action in wound healing.

Observing the tediousness of sewing a full thickness skin graft, while assisting Dr W. A. Steel, Dr Sano applied her observations made during tissue culture to experimental skin grafting in November 1941. Full thickness skin grafts were transplanted by adhesion on rats, a suspension of the buffy coat and heparinized plasma being used. The grafts united rapidly and the experiments were successfully repeated on guinea pigs. The hair grew so luxuriantly from the graft that in a few weeks it was difficult to locate the grafted area. In September 1942 she had her first opportunity to use the method in human practice in a grafting by Dr W. Emory Burnett. The result was impressive and in a recent case of his the patient was walking upon a graft on the heel within a week.

Other observations suggested that epithelization of the granulating wound about the





We are impressed with the diagnostic accuracy of the method and believe that Papanicolaou's work should be brought to the attention of the profession.

A negative diagnosis should not be accepted as final in any patient with a suggestive history or examination. In any suspicious case a negative smear must be checked by many more slides and by examination of biopsy material. A positive diagnosis does not mean that radical surgery or radiation should be undertaken but indicates that confirmatory biopsies of the cervix or endometrium should be performed. Any patient with a positive vaginal smear who is without clinical evidence of cancer should be followed closely by repeated examinations and smears. In view of the observations made by Papanicolaou and by our group that the abnormal cells seen in these smears are actually tumor cells, great risks are

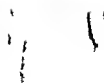
assumed by any physician who fails to follow with extreme care a woman with a positive vaginal smear.

The ease with which material for diagnosis can be obtained by this method makes the technique adaptable to office and out-patient department practice. However since the recognition of cancer cells in the vaginal smear requires an experienced knowledge of cytology it is suggested that there should be in every hospital a service for the interpretation of smears, just as there is for other laboratory tests. The possibility of State Public Health Departments offering such a diagnostic service is not unreasonable.

It is my opinion that no longer can the vaginal smear be omitted from the routine examination of any female patient who is in the cancer age group.

JOE VINCENY MILES





*Type and Stages  
John L. Sefton*

*Protest  
edith Dick*

3 1/2

# SURGERY

## GYNECOLOGY AND OBSTETRICS

*An International Magazine, Published Monthly*

VOLUME 77

DECEMBER, 1943

NUMBER 6

### HIGH ALTITUDE FROSTBITE

#### Preliminary Report

LOYAL DAVIS, M D, F A C S, Colonel, M C, A U S, Chicago, Illinois

JOHN E. SCARIF, M D, Major, M C, A U S, New York, New York

NEIL ROGERS, M D, Major, M C, A U S, Oxford, England

MEREDITH DICKINSON, M D, Lieutenant, M C, A U S, Rochester, New York

COLD damage to the extremities suffered by the high altitude airman is unique among injuries of thermal origin. It differs from the common frostbite as greatly as the "Bird's Lyé" frozen foods differ from cold storage foods. One fundamental fact is common to these injuries, to the frostbite incurred by ground troops during severe winter weather, and the immersion foot of shipwrecked seamen, namely, that the primary agent which produces the pathologic changes in the affected tissues is cold.

The secondary mechanisms, however, which operate to make the tissues particularly vulnerable to cold differ between common frostbite, immersion foot, and the frostbite of the high altitude flyer, and in the latter case are, in many respects, unique.

In high altitude frostbite, for example, extreme degrees of cold ( $-40$  to  $-52^{\circ}\text{C}$ ) are encountered. The effect of these low temperatures upon the tissues of the extremities is further augmented by varying degrees of anoxemia and ischemia. In the frostbite incurred by ground troops the flat surfaces of

the face and of other exposed portions of the body, as well as the extremities may be attacked, whereas, in high altitude frostbite one of the most striking features is the predilection for the extremities. In immersion foot, the degree of cold is moderate in comparison and the secondary factors are venous stasis, maceration of the skin by sea water, infection of the soft parts introduced through the macerated skin, malnutrition, and lowered general vitality due to sheer physical exhaustion. In the frostbite of the high altitude flyer the exposure to cold may last only a few minutes, whereas in the frostbite of ground troops or the immersion foot of the seaman, the exposure to cold may be for days or even weeks.

#### CLINICAL TYPES

*Mild type* It is quite common to find that an airman removes his gloves in order to make some necessary adjustment of his equipment. This may require only a minute or two. However, during this brief time the fingers become painfully cold, numb, stiff, waxy white in appearance, and completely insensi-

tive to touch. They feel hard and even brittle when palpated and if the fingers are struck against a hard object the sound produced is similar to that which would follow if a piece of wood were struck against the same object. The fingers cannot be flexed or extended voluntarily and often are so stiff that they cannot be moved with the other hand.

Recovery from this condition may be quite slow even after removal to a warmer environment and quite often hours elapse before the tips of the fingers begin to soften. Even after the tissues become less hard and approach normal the waxy or ashen white ischemic appearance may persist for several more hours (Fig. 1). The surface temperatures, as recorded by thermocouples attached to the finger tips may be 4 to 6 degrees (C) colder than the corresponding fingers of the unaffected hand. Capillary microscopy of the affected fingers at this early stage shows no blood what ever in the terminal capillaries on the dorsum of the fingers about the nail beds (Fig. 2). This would appear to be the result of an initial intense vasomotor spasm of the terminal portions of the arterioles and in some instances, to a secondary thrombus at the point where the arteriole with its muscular wall, passes into the thin walled capillary. These findings will be presented in detail in the discussion of the pathology to follow.

If at this stage, the individual's extremities and body can be brought back to the normal body temperature, no permanent ill effects may result. His fingers, however may ache and throb for several hours and paresthesia may persist for days or weeks but there will be no blistering, gangrene or other gross anatomical residuals.

**Severe types.** If the exposure to cold is prolonged permanent damage to the tissues of the extremities will occur and definite clinical manifestations of severe damage become apparent. These sequelae follow two patterns which for convenience may be described as the "wet" and the "dry" forms. The fundamental pathology of the two types is essentially the same.

In the wet type multiple small cutaneous blisters appear rather simultaneously upon many points of the skin of the affected part

which rapidly grow in size and coalesce to form one or several huge blisters involving the dorsum of a finger or even the dorsum of the entire hand. These may be similar to the simple vesicles incurred in second degree burns and contain free fluid but more often the blisters differ from the blisters of burns in that the pathologically excessive fluid is located fast within the tissue composing the superficial layers of the skin. The blisters may have the appearance of simple vesicles containing free fluid but if an attempt be made with syringe and needle to aspirate the fluid none or only a very small amount can be obtained (Fig. 3a). However fluid will slowly ooze from the needle puncture holes for many hours. This fluid may be a clear transudate (Fig. 4a) or it may contain blood corpuscles (Figs. 5a, b). The latter rapidly turn a dark color and impart to the affected parts an appearance easily mistaken by the uninitiated for gangrene (Fig. 15a). This dropical condition tends to persist for 2 or 3 days after which the fluid disappears and the superficial layers of the skin become loose and wrinkle then dry and hard.

Hemorrhage usually takes place beneath the nails giving them the same appearance as a nail which has been crushed and in such cases the nail is lost.

In both the simple vesicles and in the dropical blisters the superficial layers of the skin are dissected away from the deep layers by extravasated fluid. When this skin dries and hardens it is cast off frequently in the form of a complete cast of the part (Fig. 7). The separation occurs just beneath the basal germinal layer of the epithelium so that the greater part of the germinal layer comes away with the cast (Fig. 8). Epithelial regeneration later on is possible therefore only from the remnants of the germinal epithelium remaining in ducts of the sweat glands in the same manner as re-epithelization occurs at the site from which split thickness skin grafts have been taken.

The newly regenerated skin is thus tightly drawn smooth, shiny and varies in color from a dusky pink to a dark blue (Fig. 16). The exact color fluctuates freely from one extreme to the other with changes in the

temperature of the environment. The part is extremely sensitive to cold. On cool mornings the fingers have a dusky blue color, feel cold, and are painful. As the environment and the patient's own body warm up, the fingers tend to become pink in color, warm, and free from pain. This reflex warming, however, is never as great as in the normal hand. Cold tolerance is strikingly reduced. Whereas the normal hand placed in an environment minus 20 degrees centigrade will resist freezing for over an hour, the hand which has been frostbitten, placed in the same environment will freeze within 10 to 20 minutes (Fig 9).

After periods of time varying in individual cases according to the severity of the injury, the skin gradually resumes a normal appearance, normal subjective and objective reactions to environmental cold, and the capillary loops slowly regenerate. However, this requires months and, in some of the cases studied, complete anatomical and physiological recovery of the skin to normal has not occurred after 8 or even 10 months.

Anesthesia or hypesthesia to pain and touch is always present to some degree in the affected extremities and commonly extends well proximal and beyond the areas of apparent damage to the skin itself (Fig 10). These changes may persist for months (Fig 4b).

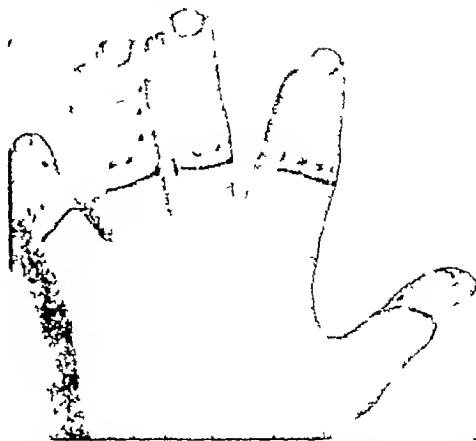


Fig 1 Photograph of hand 7 hours after exposure to temperature of  $-40$  degrees centigrade showing persistent blanching of the fingers due to vasoconstriction.

Loss of sweating usually occurs in the same areas as the impaired sensation and lasts as long as the sensory loss continues (Fig 4b).

The dry type of high altitude frostbite is usually associated with a more severe exposure to cold. In its initial stage it is indistinguishable from the wet type. The extremities may be literally as hard as rock and require longer to thaw out. At about the time that blisters would appear in the wet type, none develop in the dry type. Instead, the affected parts become very tense, the skin assumes a dull ground glass appearance.

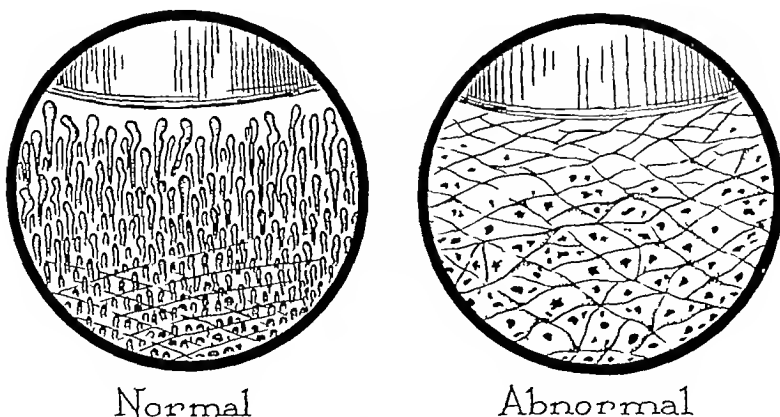


Fig 2 Drawing of the microscopic appearance of the capillary bed at the base of the nail in normal finger and in frostbitten finger. Note the hairpin appearance of the normal parallel capillary loops which are absent in the affected finger. The thrombosed stumps of the arterioles are characteristic of the frostbitten finger.



Fig. 3 a, Typical blister formation in moderately severe frostbite. The index finger shows simple vesicle which has completely collapsed following incision. The middle finger shows blister which has failed to collapse following liberal incision due to the fact that the excess fluid is held within the tissues. Both blisters are non-hemorrhagic. b, The same fingers a month later after the blisters had dried and desquamation had taken place. Not loss of nail and the absence of normal skin markings and the delicate, tight, shiny new epithelium. These fingers remained sensitive to cold for many months.

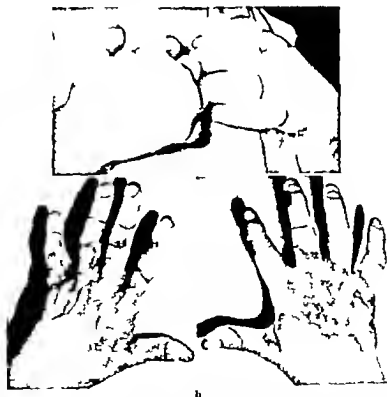


Fig. 4 a, Photograph shows severe example of blistering in the wet type of high altitude frostbite 24 hours after injury. b, same hands a month later showing regeneration of lost nails. The skin in the blistered areas is beginning to recover its normal surface markings. Sensory disturbances and loss of sweating persisted for many months.

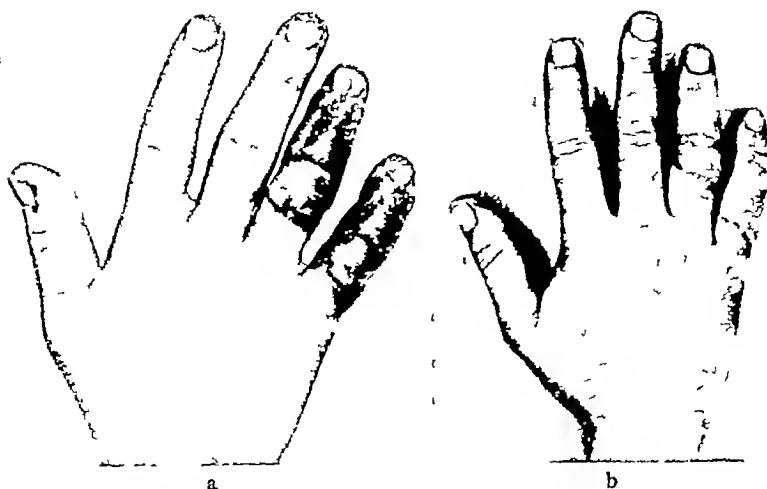


Fig 5 a, Hemorrhagic blisters in a moderately severe frostbite. Note discoloration of the nails. b, Same hand 10 days later. The blisters have dried up and the skin has an ecchymotic appearance. Desquamation occurred later.



Fig 6 Photograph showing example of severe hemorrhagic blistering in the wet type of high altitude frostbite 24 hours after injury.

(Fig 11a) and the deeper tissues take on a dusky gray color which gradually becomes darker and darker. As time goes on the skin becomes quite dry and the deeper tissues become darker and darker (Fig 12a, b, c). All the tissues shrivel and mummify and eventually become completely hard and coal black (Fig 13a, b). These changes are always more marked at the distal end of an extremity, the proximal phalanx is never involved unless the more distal ones are affected. Demarca-

tion between the black, dry, mummified distal portion of the finger and the vital tissue becomes sharp, usually after 2 or 3 weeks. Spontaneous natural amputation will take place if time is allowed, but this process is usually hastened by surgical intervention (Figs 14a, b, 15a, b, 16a, b, 17a, b, c).

#### PATHOLOGY

From a pathological viewpoint, the most striking feature of high altitude frostbite is the



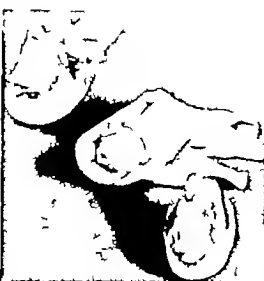


Fig. 7. Caud-desquamation of the tips of the fingers which followed severe blistering in case of the wet type of high altitude frostbite.

Fact that whereas the face may be exposed to severe cold for several hours without apparent damage, exposure of the fingers to the same degree of cold for only a few minutes may produce damage to tissue so great that gangrene and loss of fingers will result. It must be assumed that the inherent tolerance for cold in a warm blooded animal having a relatively constant body temperature is essentially the same for all tissue cells. It is difficult to explain the great difference in cold tolerance between the tissues of the cheek and the fingers upon the basis of the greater heat radiating surface of the fingers. The heat radiating surface per tissue mass in the fingers is three to four times greater than in the cheek but the susceptibility to cold is fifty to one hundred times greater. Therefore contributing mechanisms secondary to the primary action of cold on tissue cells must be sought for.

Generalized anoxemia when it occurs, undoubtedly plays a major rôle in the production or augmentation of tissue damage due to cold in high altitude frostbite but its effects cannot possibly be selective for tissues in one part of the body.

Localized anoxemia resulting from the ischemia produced by intense reflex vaso-



Fig. 8. Photomicrograph of section of skin from blister to the wet type of high altitude frostbite of moderate severity. Note the separation of the epidermis from the dermis and particularly that the basal germinal layer lost with the epidermis.

spasm of peripheral arterioles is undoubtedly the most important factor in establishing the peculiarly selective effect of cold upon the digits of both upper and lower extremities.

Acute peripheral vasoconstriction of the vessels in the extremities occurs almost simultaneously with the exposure to cold. It takes place principally at the terminal end of the arterioles. Direct microscopic examination of the terminal capillary beds in the finger tips soon after they have been exposed to intense cold has revealed the peripheral ends of the arterioles well filled with blood but the terminal capillary loops are entirely empty (Fig. 3). The evidence thus far obtained indicates that this vasoconstriction may persist for 24 hours or longer.

The basic morphological lesion in high altitude frostbite consists of damage by cold to the endothelium of the terminal capillary loops. In mild cases this results only in a pathologic permeability of the capillary wall but in the more serious cases a thrombus formation occurs at the arteriolar-capillary junction. Under the microscope these thrombi in the terminal stumps of the arterioles are plainly visible (Fig. 2). No thrombosed capillaries have been seen, presumably because early in the train of events they have been deprived of their blood by the intense vasoconstriction which takes place at the terminal ends of the arterioles.

If the vasoconstriction of the arterioles is relaxed before the thrombosis takes place and the capillary bed is flooded with blood extrav-

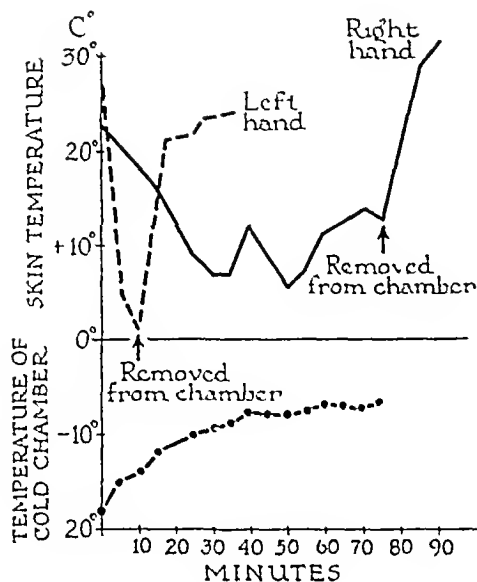


Fig. 9 Chart showing cold tolerance of normal and frostbitten hands. The lower curve represents the temperature of the experimental cold chamber (Greene). The solid line represents the temperature of the normal right hand and the broken line the temperature of the frostbitten left hand. The curves in each instance are the mean of the skin temperatures taken from the four fingers by electro-thermocouples. Note that the normal hand could not be reduced in temperature below plus 5 degrees centigrade after 50 minutes in the cold chamber. At that point it spontaneously began to warm up and in 25 minutes the skin temperature rose 4 degrees centigrade. After removal from the cold chamber the hand quickly reached a temperature 8 degrees higher than in the beginning. In contrast 10 minutes after introduction of the frostbitten left hand into the cold chamber, the skin temperature of this hand fell to almost zero and the hand became so painful that the patient's condition forced removal of the hand from the cold chamber. After removal from the cold chamber the skin temperature did not return to the original temperature.

asation of plasma or whole blood may occur through the damaged capillary walls into the tissues. This extravasated fluid may be held within the skin which then assumes a dropsical appearance, or it may collect as free fluid in vesicles. Eventually, the transudate accumulates in the tissue plane between the epidermis and the dermis immediately beneath, or deeper to, the basal germinal layer of cells of the epidermis. The germinal layer and the terminal capillary loops are dissected away from the underlying tissues. Small, irregular capillary loops begin to grow out of the stumps of the thrombosed arterioles after 3 to 4 months



Fig. 10 Photograph of hand 7 hours after exposure to temperature of  $-40$  degrees centigrade. Solid lines represent limits of hypesthesia; dotted line, limits of hypalgesia. In the index and little fingers there was a complete loss of pain and touch over the distal phalanges.

but 6 to 10 months may elapse before the appearance of the capillary bed approaches the normal. If a secure thrombosis has developed within the vessels at the arteriolar-capillary junctions before the release of the vasospasm, then the extravasation and blistering do not follow.

If the damage extends more deeply to affect the capillaries beneath the deeper fascia planes which supply muscles and bone, extravasation and hemorrhage occur in these tissues, causing increased tension and severe pain. When thrombosis occurs in the arterioles supplying these deeper tissues, dry gangrene follows. In such cases superficial blistering of the skin may not occur since the blood supply to the skin has been interrupted in the deeper tissues. The clinical picture simply progresses directly from injury by cold to dry gangrene.

The arteries show interesting changes. In 3 cases, requiring amputation of the little finger 3 months after injury from cold, the smaller arteries and arterioles showed a remarkable thickening of the intima which was eight to ten times the normal (Fig. 18). The vessels resembled those seen in cases of endarteritis obliterans. The endothelial lining of the vessels was everywhere intact, no thrombi were seen and nowhere was there a suggestion of recanalization of an earlier thrombus. The



FIG. 1. a, Photograph of an early stage of mild case of the dry type of high altitude frostbite. There is no blistering but note the ground glass appearance of the skin of the lower tips. The deeper underlying tissues are under great tension and are quite painful. Gangrene of the affected parts followed. b, Same hand 5 months later showing the loss of nails and tissue of the finger tips.

mechanisms producing these changes are not clear. However such changes are said to follow long repeated vasomotor overactivity. The veins were not involved in these pathological changes.

Neural injuries are suggested clinically by the sensory changes in the skin and by the topographical and chronological relationships existing between sensory loss and loss of sweating. Histological studies of nerves have not been successfully made because of the difficulty in obtaining suitable tissue. Whether

or the loss of sweating is due to local damage to sympathetic nerve fibers or to direct injury to the sweat glands themselves has not as yet been definitely established.

#### TREATMENT

The treatment of high altitude frostbite must be directed in the first instance to the prevention of these injuries by reducing the necessary exposure to cold and the risks of general anoxemia. These factors are always subject to dislocation in the heat of battle.



FIG. 2. a, Photograph of an early stage of severe case of the dry type of high altitude frostbite 1 hour after injury. b, Photograph of the same hand taken 3 days

later showing almost total absence of blistering. c, The same hand photographed 3 weeks later showing far advanced dry gangrene.



Fig 13 a, Photograph of a severe case of the dry type of high altitude frostbite 10 hours after injury (sulfanilamide powder dressing) b, Same hand 5 weeks later showing spontaneous amputation by dry gangrene.

and their reduction falls within the province of the tactician and the engineer

Localized anoxemia of the extremities due to reflex vasospasm is, however, a straightforward medical problem. Its prevention and treatment present a challenge to the physician.

Three types of protective ointments have been studied upon the extremities of normal individuals and patients in whom cold damage has occurred from the viewpoint of preventing the lowering of skin temperature. Careful studies of skin temperature readings after con-

trolled exposures to cold have not yielded results which would indicate that such a line of investigation would prove profitable.

Release of vasoconstriction and its attendant ischemia appear to be a matter of prime importance in the treatment of these cases and must be obtained early if the measure is to be effective, that is, before thrombosis has taken place. Vasodilatation may be brought about in the extremities in several ways.

The simplest way to produce vasodilatation is by the local application of heat, but the de-

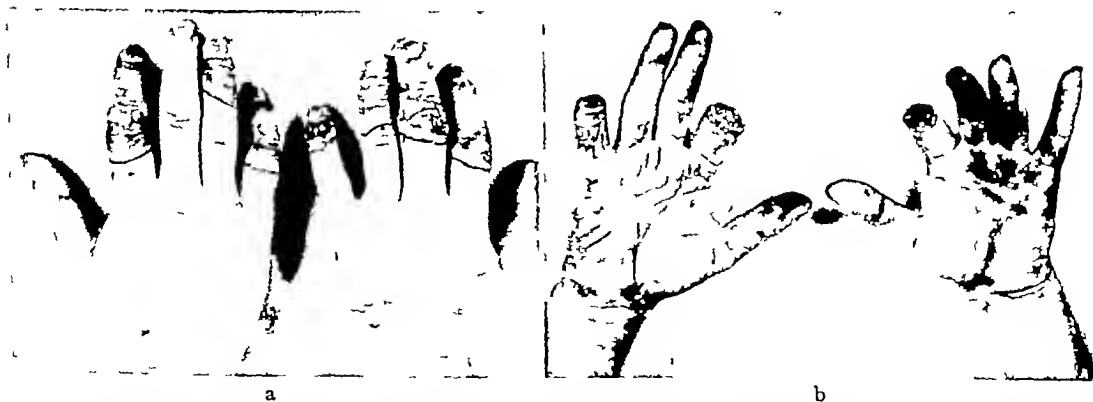


Fig 14. a, Photograph of a severe case of the dry type of high altitude frostbite 10 days after injury. Note the early

stages of mummification and dry gangrene b, One month later after guillotine amputation of gangrenous parts



Fig. 5. a, Photograph of an extreme case of the dry type of back-bitten frostbite 10 days after injury showing absence of blistering and the developing dry gangrene in the little finger of the left hand. The thumb and index

fingers of the right hand show the late stage of hemorrhagic blisters in which the skin only has turned hard and black. b, Same hands 5 months later.

gree of warmth which should be applied to a frostbitten extremity during the early hours or days of treatment is a moot question. Greene (1) has recommended that the frost-bitten extremity be kept at a temperature approximately plus 2 to plus 5 degrees centigrade because in his opinion (1) heat to the frozen part increases its metabolism and its oxygen requirements and encourages the growth of bacteria and (2) because warmth increases the flow of blood to the part, resulting in greater transudation and blistering. Greene cites Lake's work which showed that the survival rate of tissue cultures is greatest between minus 1 degrees centigrade and plus 5 degrees centigrade.

In line with this reasoning Greene has devised a therapeutic refrigerator (2). It contains one compartment in which solid carbon dioxide is placed and a second compartment into which the frostbitten extremities may be placed. The former communicates with the latter through vents which can be opened and closed as desired to regulate the temperature which is recorded by a thermometer and can be read from outside the box. It is possible to reduce the temperature in the compartment in which the extremities are placed as low as minus 20 degrees centigrade. He advises treatment of frostbitten extremities by placing them in the cabinet with the temperature of the air in the compartment set at plus 2 or 3 degrees centigrade and keeping them there for several days, or even a week, until their

removal from the cold cabinet to room temperature is no longer followed by pain in the parts.

We have found Greene's refrigerator an ingenious apparatus and very useful for establishing controlled conditions for studying the effect of cold upon normal and frostbitten extremities. We are not yet prepared, however, to accept without reservation his ideas regarding the therapeutic value of cold in the treatment of the cold damage incurred by high altitude fliers.

It does not necessarily hold that because temperatures between minus 5 and plus 5 degrees centigrade are optimum for tissue cultures *in vitro* bathed with nutrient fluid the same temperatures are optimum for the metabolism of adult tissue cells *in vivo* and dependent for their vitality upon the exchange of gases in the circulating blood. Sir Thomas Lewis (3) states categorically: "If the skin is sufficiently cold, 10 degrees centigrade (50 degrees F) or less, the blood will not part with its oxygen." If we assume Lewis to be correct it seems illogical to reduce the temperature of the already damaged tissues below 10 degrees centigrade to the levels of 2 to 5 degrees centigrade recommended by Greene. The point stressed by him that the metabolic requirements of the tissues are lowered at the temperature he recommends seems of little consequence in comparison with the fundamental fact that no oxygen is released by the blood to the tissues at these temperatures.



Fig 16 Photograph of a case which showed mixed features of both wet and dry types of mild high altitude frostbite a, Hemorrhagic blistering soon after injury b, Same hand 3 months later showing dry gangrene of deeper tissues Note sharp line of demarcation between viable and gangrenous tissue

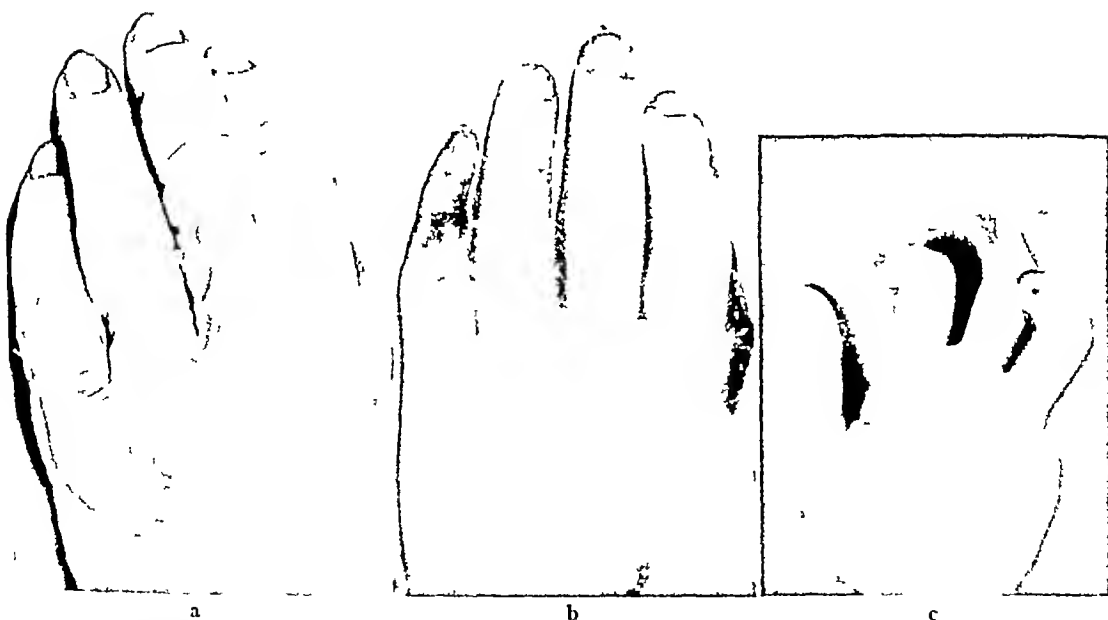


Fig 17 Photograph of a case which showed mixed features of both wet and dry types of severe high altitude frostbite a Huge vesicular blister 72 hours after injury

b Same hand 10 days later showing dry gangrene developing in the deeper tissues of the finger tips c Same hand 5 months later



Fig. 8. Photomicrograph of cross section of small artery centimeters proximal to the line of demarcation of gangrene in an amputated finger from severe case of high altitude frostbite of the dry type. Note the marked thickening of the intima and the absence of central thrombus or evidences of recanalization. The endothelium is intact.

Our studies have shown that great differences in temperature usually exist between the environment and the surface of the extremity. Great variations in these differences of temperature are found between the two hands of the same individual if one is normal and the other is damaged by cold. Also great differences between environmental and surface temperatures may be found in the same hand with variations in the general level of the environmental temperature and the duration of exposure to that temperature. Only by taking temperature readings frequently directly from the skin itself and preferably with an electric thermocouple can the actual temperature of the tissues of an extremity be accurately known or even approximately judged. This is all clearly shown in Figure 9. The frostbitten left hand and the normal right hand of a patient were placed in the cold chamber the temperature of which was minus 8 degrees centigrade. The temperature of the affected left hand at the beginning of the experiment was plus 28 degrees centigrade and that of the normal right hand was plus 23 degrees centigrade. Ten minutes later the temperature of the affected left hand had fallen to plus 1 degree centigrade and that of the normal right hand to plus 18 degrees centigrade. At this

point the damaged left hand was removed from the cold box but the normal right hand was kept in the box. Forty minutes later the temperature of the right hand had fallen to plus 6 degrees centigrade and the temperature of the cold box had risen from minus 14 degrees centigrade to minus 8 degrees centigrade.

It has been noted by many observers, including ourselves, that a frostbitten hand is more apt to blister if it is rapidly warmed or warmed above normal body temperature than if it is kept cool. Greene reasons that this is because with the warming, blood returns in large volume into capillaries whose walls have been damaged and have suffered pathological increase in permeability. Transudation takes place through these damaged walls into the adjacent tissues, thus causing the dropsical and vesicular blisters already described. With this we are in agreement. Greene also believes, however, that the most important objective in the early immediate treatment of the frostbitten hand is to prevent the formation of blisters and he would do this by restricting the quantity of blood flowing into the capillary beds by continuing peripheral vasoconstriction. This vasoconstriction he proposes to obtain by keeping the damaged parts cold and advises keeping them in a temperature slightly above freezing from the time of injury to as long as several days. We are not prepared to accept this form of treatment at this time.

In an effort to evaluate Greene's recommendations for treatment by continued cooling we have treated a series of cases by keeping the damaged parts at controlled temperatures approximating those advised by Greene for periods ranging from 24 to 48 hours after the injury had been sustained. Simultaneously we have treated a second series of cases by exposing the damaged parts to room temperature, thus allowing a spontaneous refilling of the capillary beds at a natural rate and to a normal degree without attempting to interfere with natural physiological reparative processes. In our judgment the results obtained by this method were equal or better than those obtained by continued cooling. It is our impression that less blistering occurred in

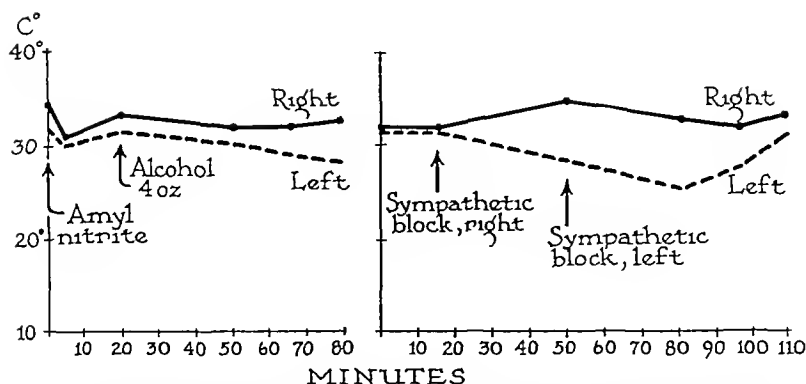


Fig 19 Chart showing effect of amyl nitrate, alcohol and sympathetic nerve trunk block upon a case of moderately severe high altitude frostbite of both hands within an hour of injury. Thermocouples were applied to the finger tips and the capillary beds at the base of all the finger nails were examined microscopically. No blood was present in any of the capillary beds of the affected fingers. Amyl nitrate inhalation (ampuls 2) was given without filling of the capillaries. The surface temperatures of the finger tips fell sharply. Alcohol (4 ounces) was given to the patient and similar readings and observations were carried out at frequent intervals. The capillaries did not fill with blood. The surface temperatures of the finger tips of both hands dropped slightly but was more marked in the more seriously damaged left hand. Paravertebral block with 2 percent novocain was performed at the level of the first rib, produced opening and filling of the capillaries with blood, progressive rise in the skin temperature readings and appreciable warming of the right hand. On the left side, no blood was seen to enter the capillaries and there was a slight decrease in the surface temperature readings of the finger tips. The curves represent the mean surface temperature readings taken from three fingers of each hand.

those patients treated by cooling but on the other hand, the patients as a group, complained more of pain and required more sedation than those treated by exposure to room temperature and there was ultimately a greater loss of tissue.

It has been our plan whenever patients were received with two extremities equally damaged to treat one extremity with the continued application of cold and to treat the other extremity by exposure to room temperature. To date we have had only one patient considered suitable for such a controlled experiment. This patient came under treatment soon after he had received cold injury to both hands which to us appeared about equally damaged. Thermocouples were attached to the five digits of his left hand and the extremity was placed in cold packs for 48 hours. Skin surface temperature readings were made every 15 to 30 minutes during this period. The right hand was exposed to room temperature. During the 48 hours of observation the patient complained of more pain in the hand treated by cold than in the other hand. The

stages in the subsequent course in the two hands was very similar. Moderate blistering

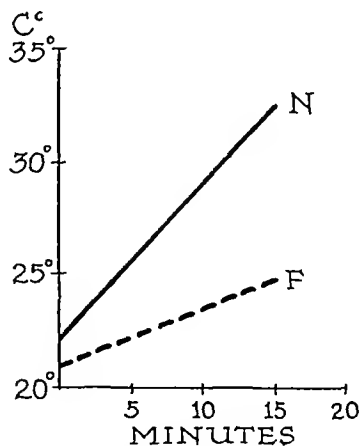


Fig 20 Graph to show reflex warming of normal and frostbitten hands. The patient was seated in a room of average temperature, and his feet immersed in warm water at 46 degrees C (115° F), for 15 minutes. The solid line shows the mean rise in the skin temperatures of the finger tips in a normal hand. The broken line shows the mean rise in the skin temperatures of the finger tips in a hand which had suffered moderately severe frostbite 2 months before.



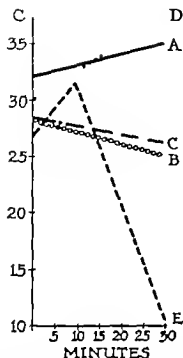


Fig. Graph to show the effect of sympathetic block on the surface temperatures of frostbitten hands. 1. Each instance block of the sympathetic trunk as made para-vertebrally with per cent novocain at the level of the first rib.

A. Mild case—4 hours after exposure. Vasospastic action of the terminal arterioles still persisted, but thromboses had not taken place. Immediately after block as indicated the capillary loops in the finger tips again filled, because visible under the microscope, and the skin temperatures rose.

B. Moderate case—24 hours after exposure. A vasospastic and thrombosis of the terminal arterioles as present. Sympathetic block failed to cause elevation of skin temperature or refilling of capillaries in the finger tips.

C. Moderate case—6 weeks after exposure. Thromboses had occurred at the time of injury in this patient. Regeneration of the destroyed terminal capillary loops had not yet begun at the time this block as made.

D. Moderate case—6 months after exposure. Partial regeneration of capillary loops had taken place in this patient. Sympathetic block caused moderate warming of the finger tip at room temperature.

E. Moderate case—6 months after exposure. The same patient as in D. Following block patient as kept at room temperature for minutes, during which time active warming took place. The hand was then placed in cold chamber (temperature  $-20$  degrees C.). Not the precipitate fall in the surface temperature of the hand. This patient tolerance to cold as still below normal and he is still unfit for high altitude flying.

and desquamation occurred in both hands. Following this there was the usual appearance of the remaining skin and both hands became

blue and painful in cold weather. However these reaction were more marked in the hand treated by the application of C. D.

Other methods of releasing peripheral vasoconstrictions are (a) by applying heat to the body as a whole which produces a generalized dilatation of peripheral blood vessels in all extremities and thus produces reflex warming (Fig. 20) (b) by the action of drugs (such as amyl nitrate nitroglycerin alcohol the salicylates and papaverine) which affect directly the musculature of the blood vessel walls (c) by the action of drugs which act primarily upon the autonomic nervous system which in turn acts upon the blood vessel walls through the medium of the sympathetic motor fibers (nicotinic acid, mechoilin) and (d) injection blocking of either the peripheral nerve or sympathetic nerve trunks.

As previously stated if any of these measures are to be effective they must be carried out before thrombosis has taken place at the arteriolar-capillary junctions. Optimum results can be anticipated if the defrosting and the release of vasospasm can be accomplished while the alman is still in flight. Chemical methods for producing relaxation would obviously have great advantages over nerve blocking procedures which require exacting surgical skill.

With this in mind we have carried out experiments with amyl nitrate nitroglycerin alcohol and aspirin. These drugs were administered both to normal persons and to patients who had recently received injuries to their fingers from excessive cold. The effect of these drugs on the peripheral capillary circulation was studied by means of electric thermocouples and simultaneous direct microscopy of the capillaries themselves. Contrary to the generally accepted action as reported in textbooks none of these drugs caused an elevation of the temperature in the tested parts nor did they cause a dilatation of the capillaries bed (Fig. 19).

Similar experiments with drugs acting upon blood vessel walls through the medium of the autonomic nervous system have also been carried out with similar negative results.

Blocking of the sympathetic nerve trunk and the stellate ganglion with novocain has

been performed in patients suffering at the time from acute vasoconstriction as a result of exposure to intense cold. The results obtained tended to establish the fact that acute dilatation of the peripheral capillary bed could be effected in extremities in which there had not been permanent anatomical injury to the capillary wall, or thrombosis at the arteriolar-capillary junctions. On the other hand, as would be expected in the more seriously affected extremities in which these two patho-

logical changes had already occurred, blocking of the sympathetic trunk and the stellate ganglion failed to produce either a rise in the skin temperatures of the finger tips or a re-appearance of blood in the terminal capillary beds (Fig 21)

#### REFERENCES

- 1 GREENE, RAYMOND *Lancet*, Lond, 1941, 2 689
- 2 *Ibid*, 1942, 2 695
- 3 LEWIS, SIR THOMAS *Vascular Disorders of the Limbs*  
P 9 London Macmillan and Co, 1936

# PRIMARY ENDOMETRIOSIS OF THE CERVIX UTERI

A. F. LASH, M.D., Ph.D., F.A.C.S., and H. RAPPAPORT, M.D., Lieutens 1, M.C. A.U.S.  
Chicago, Illinois

**P** RIMARY endometriosis of the cervix uteri is rare. Hobbs and Lazar in a recent case report of this condition, found only one authentic case recorded in the literature. These authors believe that most of the other reported cases of cervical endometriosis have been either extensions from endometriosis of the rectovaginal septum or cases in which cystically dilated cervical glands were found deep in the fibromuscular stroma. However a careful search of the literature revealed 3 more cases which can be considered as primary endometriosis of the cervix. A 6th case will be reported in this paper.

## REVIEW OF LITERATURE

Fels reported the case of a 33 year old unmarried nullipara who on first admission, complained of vaginal discharge and right lower quadrant pain. Retroflexion of uterus and chronic appendicitis were diagnosed. A ventrifixation and appendectomy were performed. Four months later pain was still present and her menses were irregular. On examination the uterus was found to be well fixed anteriorly. A scar was found extending from the cervix to the left side of the vaginal vault. Three dark red nodules, each about 3 millimeters in diameter forming a chain were present on the left side of the cervix. Neither the scar nor the nodules were seen when the patient was examined at the time of her first admission nor was there anything in the history which would suggest the possible origin of the scar. A portion of the cervix containing the scar and the nodules was excised. Histological examination showed the squamous cell epithelium of the cervix intact except in those areas where the nodules were located. Here it was absent and there was instead typical endometrial stroma with glands in the premen-

strual stage. Recent hemorrhages were seen on the surface. Islands of endometrial tissue and evidences of old hemorrhages were present also in the deeper layers of the fibromuscular wall of the cervix. In view of the persistence of the patient's complaints Fels considered the possibility of adenomyosis of the uterus. The patient refused another operation.

The superficial location of the nodules and their presence in the immediate vicinity of a scar suggest that this was a case of primary transplantation of endometrial tissue to the vaginal portion of the cervix. In view of the fact that only a small portion of the cervix was available for examination that islands of endometrium were found also in the deeper layers of the fibromuscular wall and that the patient's complaints persisted after excision of the lesion, an extension from the rectovaginal septum or from the serosal surface of the supravaginal portion of the cervix cannot be excluded with certainty. These extensions, however are usually located on the posterior cervical lip. Furthermore no evidence of pelvic endometriosis was found at the time of the first operation. That islands of endometrium were found also in the deeper layers can be explained by the presence of the scar in which endometrial fragments may have become entrapped.

A second case was reported by Rushmore.

A 36 year old primipara complained of slight brownish discharge from the vagina which had started day after her menstruation was due. Four years prior to this patient had given birth to a child at term. Version and extraction were done for teriac inertia. Examination revealed small polypoid nodule of the vaginal portion of the cervix, the right of the os, about quarter of an inch in diameter discharging dark brownish fluid. Histological examination of the excised lesion showed endometrial glands surrounded by decidua. T and half cck later patient returned stating that the bleeding continued. Dark, blood-stained discharge as present. The growth on the cervix was from two to three times as large as before the first removal and there was slight bleeding. The endometrial implant as

From the Departments of Gynecology and Pathology, Mount Sinai Hospital, Chicago, Illinois.  
Dr. Rappaport now at Station Hospital, Camp MacKall, North Carolina.

excised and the uterus curetted, normal tissue of early pregnancy was obtained

The author concluded that at the time of the first operative delivery some of the loosened endometrium probably became attached in the laceration of the cervix and during the ensuing pregnancy underwent "normal hypertrophy." The hypertrophy and bleeding in pregnancy suggested a carcinoma of the cervix but this could be ruled out by the histological examination

Fobe reported the 3d case in a 23 year old nullipara

After 2 years of marriage she consulted a physician because of dysmenorrhea and sterility. He diagnosed a retroversion, did a curettage followed by inguinal shortening of the round ligaments. Shortly afterward she became pregnant but aborted in the 3d month. About 1½ years after the operation the patient, then in the 3d month of her second pregnancy, noticed a brownish discharge from the vagina. A small elevation, about the size of a hazelnut, was present on the anterior lip of the cervix. The lesion was excised. The histological diagnosis was endometrioma with decidual reaction. A month later the cervix was completely healed. She had an uncomplicated delivery at term.

This case can be considered as primary cervical endometriosis. The localization of the lesion in the superficial portion of the anterior cervical lip would by itself strongly support such a diagnosis.

Hobbs and Lazar reported the following case

A 40 year old white woman complained of irregular vaginal bleeding, pain in lower abdomen, and backache. In 1932 she had a uterine suspension, left salpingo-oophorectomy, right salpingectomy, and appendectomy. She had two pregnancies 12 and 14 years ago, which terminated in normal deliveries. A chronic cervicitis with an irregular and enlarged corpus was found. A complete hysterectomy was done. The corpus uteri was enlarged two and one-half times. There were dense adhesions to the left side of the pelvis, the omentum, the bladder, and the sigmoid. There was no evidence of pelvic endometriosis. Examination of the cervix showed the portio covered by normal epithelium and its surface smooth and glistening. The cervical canal was normal with the exception of a small brown area, 0.5 centimeter in diameter, near the external os on the right side. Sections showed typical endometriosis. Many sections from the posterior portion of the cervix and the uterus showed no evidence of endometrial tissue.

In this case the entire uterus was available for examination and endometriosis was found only in the cervix.

The 5th case was reported by Henriques

A 40 year old married woman, one night during her menstrual period, suddenly had a severe vaginal hemorrhage. Menstrual periods had been normal since the age of 15. The patient had had 9 normal deliveries, the last about 8 years prior to the present episode. For the past 8 years she had been suffering from dysmenorrhea. The vulva was covered with dark red, partly clotted blood. On the vaginal portion of the cervix was seen a soft, bleeding, red mass about the size of a hen's egg. Uterus and adnexa presented no abnormalities. A carcinoma was suspected. Histological examination of a biopsy specimen revealed the presence of a hyperplastic endometrial growth. The cervix was amputated. Post-operative course was uneventful. At the time of the publication 18 months had elapsed since the operation, with the patient in perfect health and without any menstrual complaints.

This case is interesting because it closely simulated cervical carcinoma in its clinical manifestations. No case of cervical endometriosis producing such a severe hemorrhage is recorded in the literature. The author did not state whether the amputated cervix was examined histologically. For a complete evaluation of this case it would have been interesting to know whether or not the endometrial growth was confined to the surface of the vaginal portion of the cervix and whether and how far it extended into the cervical canal. Here, as in the first case, extension from endometriosis elsewhere in the uterus cannot be excluded with certainty. It is likely that the lesion was confined to the cervix, in view of the complete cessation of all menstrual complaints after the amputation of the cervix.

#### CASE REPORT

R S, a white woman, was seen by one of us (Lash) for the first time in October, 1937. At that time she was 31 years old and had been married for 13 years. She had two spontaneous deliveries (1926 and 1928) and two induced abortions (1930 and 1936). Menstruation began at the age of 15 and was regular. The flow lasted 5 days until her first abortion, 7 days since then. Since her first abortion she had been passing clots with her menstrual flow. Vaginal examination revealed the following. The vulva showed no abnormality, the cervix presented a round, hard, transverse external os, the corpus was somewhat enlarged and firm, and freely movable, the right broad ligament was thickened, fixed and tender, the left ovary was twice the size of normal. A red area, about 1 centimeter in diameter, was noted on the anterior cervical lip, about 2 centimeters from the ex-



Fig. 1. Photomicrograph of cervix showing endometrial tissue partly lined with stratified squamous cell epithelium.  $\times 5$ .



Fig. 2. Low power magnification showing the typical structure of the endometrial glands and the stroma.  $\times 92$ .

terial cervical os. Patient was administered iodine douches. She was seen again in November 1934. She complained of backache during menstruation and of spotting for several days following each menstrual period. Both symptoms had been present for the past 3 years. Pelvic findings were essentially the same as in 1932 except for the presence of dark red, hemorrhagic, slightly elevated area about the size of a pea on the anterior lip of the cervix. Carcinoma suspected. The lesion was excised and the uterine cavity was curetted.

Pathological examination revealed a wedge-shaped portion of tissue measuring 8 by 4 by 3 centimeters. On one surface there was a dark red, slightly elevated circular hemorrhagic area measuring 0.7 centimeter in diameter. It was sharply outlined and its surface appeared eroded. The section surface exposed by dividing the specimen longitudinally showed that the hemorrhagic area was 0.5 centimeter thick and separated sharply from the underlying fibrous grayish white stroma. Histological slides showed typical endometrial tissue. It was partly lined with stratified squamous cell epithelium which was continuous with the squamous cell epithelium of the adjacent portions of the cervix, and partly it was devoid of an epithelial lining and directly exposed to the surface (Fig. 1). The endometrial glands (Fig. 2) were normal in caliber or slightly dilated. They were lined with a single layer of tall columnar epithelial cells with centrally or basally located nuclei, without evidence of secretory activity. The stroma contained great deal of extravasated blood, particularly around the glands. It was in some places moderately infiltrated with lymphocytes and plasma cells. The cervical stroma in the vicinity of this area of endometrial tissue contained normal, somewhat dilated cervical glands. Some of them are immediately beneath the squamous cell epithelium. Adjacent to this the surface was partly lined with endocervical columnar epithelium, partly it was devoid of epithelial lining, and the superficial layers of the cer-

vical stroma were moderately infiltrated with lymphocytes. Sections from the uterine scrapings showed variations in size and configuration of the endometrial glands. Their epithelial lining was proliferating, chiefly with crowding of the nuclei and formation of papillary projections. There was only little evidence of secretory activity in some of the glands, but in most of them there was none at all. The stroma contained great deal of extravasated blood. Diagnosis: Cervix-endometriosus, chronic endocervicitis, healing postoperative II endometrium hyperplasia.

Three weeks after the excision the cervix healed. The menstrual period following the curettage lasted 4 days and the flow was decreased in amount. Eighteen months later the patient had no complaint whatsoever. Her menstrual periods have become normal as to interval, amount and duration.

This is a clear cut case of primary cervical endometriosus. The symptoms started after an induced abortion and subsided immediately after the excision. There was no clinical evidence of endometriosus of the uterus or of the rectovaginal septum.

#### ANALYSIS OF STUDY

The term "primary endometriosus of the cervix" should be used to designate a condition in which the presence of islands of endometrial tissue is limited to the cervix and in which extension from endometriosus of the rectovaginal septum or from endometrial implants on the serosal surface of the supravaginal portion of the cervix can be excluded.

Secondary involvement of the cervix can be excluded with certainty only if the entire uterus is available for pathological examination (case



Fig 3 High power magnification of one of the glands shown in Figure 2  $\times 295$

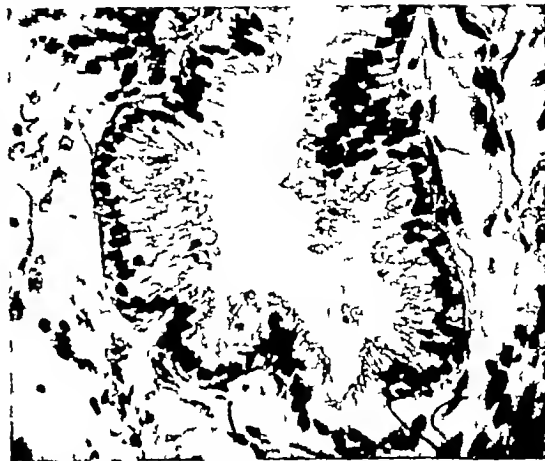


Fig 4 Cervical gland from the vicinity of the endometrial implant.  $\times 295$

of Hobbs and Lazar) In most instances, hysterectomy was not done because histological examination of the biopsy material revealed the benign nature of the lesion We believe that, on the basis of the clinical and pathological data available in these cases, the following criteria can be used in favor of the diagnosis of primary endometriosis of the cervix

- 1 Localization of the lesion on the anterior cervical lip or to the right or left of the external os (Secondary extensions of endometriosis into the cervix are usually located in the posterior cervical wall)

- 2 Presence of endometrial islands in the most superficial areas of the vaginal portion, immediately beneath the squamous cell epithelium or directly exposed to the surface

- 3 Presence of endometrial islands within scar tissue

- 4 Absence of clinical evidence of endometriosis of the uterus or the rectovaginal septum

- 5 Cessation of the clinical symptoms after excision of the lesion

From the clinical standpoint the condition is important because in the majority of cases vaginal bleeding or a brownish discharge from the vagina is the outstanding if not the only symptom This together with the finding of a dark red or brownish red elevated area or nodule on the cervix may easily lead to the suspicion of carcinoma This actually happened

in 3 of the reviewed cases and in the 1 reported by us, and only the histological examination revealed the true nature of the condition

On the basis of the clinical and pathological findings in the 6 cases of primary cervical endometriosis so far reported it seems likely that the condition is due to grafting of endometrial or decidual tissue fragments This holds true also for some cases of primary endometriosis of the vagina (Kleine) vulva (Henry), and for most cases of perineal endometriosis (Palmer, Neuweiler, Prager, Violet, Maliphant, Micholitsch) That transplantation of endometrial tissue in the lower genital tract is possible was shown by Schmid He produced artificial endometriosis of the vagina in 19 women, on whom he had to perform total hysterectomies, by placing endometrial fragments from the removed uterus into the operative vaginal wound without fixing them These grafts took in most instances, underwent regular cyclic changes and caused regular vaginal bleeding similar to menstruations, which was the purpose of the procedure It is well known that decidua has been, in a number of instances, inadvertently transplanted into abdominal wounds during cesarean sections, with subsequent development of endometriosis in the abdominal scar It is, therefore, logical to assume that also in deliveries *per vias naturales*, operative or non-operative, decidual fragments may become entrapped in cervical lacerations, vaginal or per-

ineal tears, or in episiotomy wounds and if conditions for continued growth are favorable may eventually lead to the development of endometriosis.

Pemberton and others have raised the question why endometriosis of the cervix and the lower genital tract is not more commonly seen considering the fact that menstrual blood contains pieces of viable endometrium and a curettage precedes many plastic operations on the vagina. It is questionable whether endometrial fragments normally shed during menstruation are viable enough for grafting on the intact squamous cell epithelium of the cervix. In 5 of the 6 cases mentioned in this paper pregnancies or curettements preceded the development of cervical endometriosis. In one case (1) in which no such history could be obtained the lesion was found in the immediate vicinity of a scar an indication that there must have been some operative manipulation of the cervix. Although it is accepted by some authors that endometrium cast off during menstruation may under certain conditions, implant itself on the peritoneum (Sampson) it is not very likely that the intact squamous cell epithelium of the lower genital tract would be a proper nidus for such implantation. Absence of sterile conditions in the cervix as they exist in the peritoneal cavity and the continuous desquamation of the superficial layers of the squamous cell epithelium would militate against the grafting of any kind of endometrial tissue, particularly on the intact epithelium. It seems, therefore, that a traumatic lesion, for instance a cervical laceration, or a vaginal or perineal tear is a necessary prerequisite for the implantation of endometrium in these areas. The frequent presence of some degree of infection in these lesions would however further diminish the chances of successful grafting. Hobbs and Lazar suggest that a change in hydrogen-ion concentration may be a factor in inhibiting the growth of endometrial

tissue in the cervix. It would seem that the three factors, namely absence of sterile conditions resistance of the intact squamous cell epithelium to implantation, and the frequent presence of some degree of infection in cervical erosions and lacerations, explain sufficiently the relative rarity of primary endometriosis of the cervix.

#### SUMMARY

A case of primary endometriosis of the cervix is reported. Only 5 other cases of this condition were found recorded in the literature. Clinically it is in the majority of instances characterized by vaginal bleeding with or without dysmenorrhea and by the presence of a dark red or brownish red growth on the vaginal portion of the cervix, either on the anterior cervical lip or to the right or left of the external os. In 4 of the 6 cases malignancy was suspected and could be ruled out only by histological examination. The condition is most probably due to transplantation of endometrial or decidual tissue fragments to the vaginal portion of the cervix. Its rarity can be explained by the resistance of intact stratified squamous cell epithelium to grafting and by the presence of some degree of infection in cervical lacerations and erosions.

#### REFERENCES

1. FELL, E. *Zbl. Gyn.*, 1925, 5, 285.
2. FORT, H. *Brussels med.*, 1916, 10, 616.
3. HARTOGH, J. *Arg. bras. cir. uter.*, 191, 91, 29.
4. HERR, J. S. *Surg. Gyn. Obst.*, 1927, 44, 617.
5. HOBBS, J. E., and LAZAR, M. R. *Am. J. Obst.*, 1931, 4, 509.
6. KLEIN, H. O. *Zentr. Geburtsh. Gyn.*, 1931, 64, 499.
7. MALPRACT, R. G. *J. Obst. Gyn. Brit. Empire*, 1933, 4, 957.
8. MACHOLITZ, T. *Wien. med. Woch.*, 1933, 83, 7, 5.
9. NEUBERGER, W. *Schweiz. med. Woch.*, 1926, 56, 545.
10. PALMER, A. C. *Proc. R. Soc. M.*, 1925, 8, 83.
11. PENDERGAST, F. A. *N. England J. M.*, 1917, 7.
12. PRAGER, T. *Zbl. Gyn.*, 1912, 56, 927.
13. REIDEMAN, S. *N. England J. M.*, 1913, 105, 49.
14. SAMPSON, J. A. *Am. J. Obst.*, 1915, 1, 642.
15. SCHÖN, H. H. *Arch. Gyn.*, 1933, 55, 7.
16. VIGIER, H. *Lyon med.*, 1926, 4, 6.

# ONE STAGE PANCREATODUODENECTOMY

ALEXANDER BRUNSCHWIG, M D, F A C S, Chicago, Illinois

**E**XCISION of the entire duodenum and head and neck of the pancreas in one stage for carcinoma of the ampulla, head of the pancreas, or lower common duct has been successfully performed on a number of occasions by several surgeons. Variations in operative technique have been described including methods for implantation of the pancreatic duct into the jejunum.

The writer in 1937 described a two stage procedure for resection of the entire duodenum, and head and neck of the pancreas — pancreatoduodenectomy (1). This procedure was carried out in one stage for the first time in 1939, but the patient died suddenly on the 4th postoperative day, after minimal reaction from operation. No necropsy was obtained, and the clinical impression of the cause of death was coronary occlusion. A first successful radical one stage resection was performed by Whipple in 1945. A Pólya type gastrojejunostomy, with choledochojejunostomy was the procedure employed in re-establishing continuity of the upper alimentary tract.

The purpose of this report is to record experiences in 8 patients subjected to one stage pancreatoduodenectomy. The technique originally described for the two stage procedure has been modified only in that transection above is carried out through the junction of the lower fifth or sixth of the stomach with the upper four-fifths or five sixths, instead of at the pyloric sphincter, and transection below is made in the jejunum about 3 to 6 centimeters beyond the ligament of Treitz instead of through the first 1 or 2 centimeters of jejunum, the ligament being completely divided. A choledochojejunostomy is performed instead of cholecystjejunostomy.

At the risk of repetition a summary of the operative procedure follows (Figs. 1 and 2). Continuous spinal anesthesia is used if possible and silk suture technique is followed

throughout. The chief steps in the operation are:

1. A high midline, transverse, or inverted-T incision.

2. The head of pancreas and duodenum are mobilized by incision of the peritoneum along the greater curvature of the duodenum. This step aids in ascertaining if the neoplasm has invaded the first portions of the portal vein.

3. The lower stomach is transected and the upper segment is closed. The superior pancreatoduodenal artery is divided near the duodenal wall.

4. The common bile duct is transected at or slightly below the level of the upper margin of the first portion of the duodenum.

5. The neck or proximal portion of the body of the pancreas is transected at the level of or slightly to the right of the superior mesenteric vessels. In the stump of the pancreas, the main pancreatic duct is secured in a hemostat twisted through a 90 degree arc, and ligated. The pancreatic parenchyma is sewed by interrupted interlocking mattress sutures that are not tied too tightly.

6. The superior mesenteric vessels are elevated from the uncinate process of the pancreas and third portion of the duodenum.

7. The ligament of Treitz is incised, thus freeing the duodenojejunal junction and facilitating transection of the jejunum distally.

8. The jejunum 3 to 6 centimeters distal to the ligament of Treitz is transected, and the lower segment is closed by 3 concentric purse-string sutures (linen). Duodenum, head of pancreas, and lower segment of common bile duct are removed.

9. Posterior gastrojejunostomy is done.

10. The transverse mesocolon is incised to permit the first long loop of the jejunum to be brought upward for the choledochojejunostomy. The latter may be done "anteriorly."

11. A jejo-jejunostomy is made below the opening in the transverse mesocolon between efferent and afferent loops of jejunum going to choledochojejunostomy.

From the Department of Surgery, the University of Chicago. This study was facilitated by O. C. Miller Fund for Cancer Research, University of Chicago. Presented before the Chicago Surgical Society, May 5, 1943.



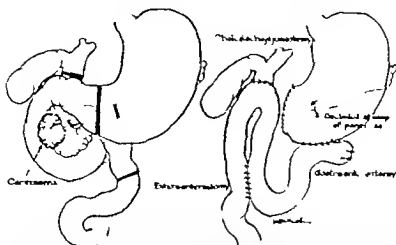


Fig. 1. a, left, Diagram shows long transections (double lines) for one stage pancreaticoduodenectomy: excision of carcinoma of head of pancreas. b, Termination of operation—re-establishment of continuity of upper alimentary tract by gastroduodenostomy, cholecystojejunostomy and enterocenterostomy. The stump of pancreas is occluded.



Fig. 2. Surgical specimen, one stage pancreaticoduodenectomy Case 6 (260720). S, lower portion of pylorus; P, bisected head, neck, and proximal portion of body of pancreas; D, large degenerating and cystic carcinoma in head; D, second and third portions of duodenum; J, 4 centimeters of jejunum beyond ligament of Treitz.

12. A soft rubber drain is applied to the site of the head of the pancreas and the abdominal wound is closed.

The 8 cases in this series are summarized in Table I. The immediate operative mortality was 50 per cent: 1 patient survived 5 months, dying of carcinomatosis; 1 survived 5 months, dying of carcinomatosis; 1 living well and doing heavy physical labor 16 months after operation; 1 is living and well after 6 months.

Several questions remain at present unsettled in connection with the newer surgery of neoplasms of the head of the pancreas and ampullary region and only tentative conclusions are now permissible.

**On stage versus two stage operation.** The two stage operation in which anastomosis of the obstructed biliary tract to the alimentary tract is the principal objective of the first stage will remain as the procedure of choice in many

edly debilitated patients. It would appear that such an anastomosis (cholechoenterostomy) alone, without additional steps, would suffice. If gastroenterostomy with or without enterostomy is performed, the entire excision might as well be carried out. A cholechoenterostomy may be performed under local anesthesia or with suitable general anesthesia if patient is not a suitable subject for spinal anesthesia. Furthermore, several procedures at the first stage favor the production of adhesions which renders the second stage more difficult.

*Cholechoenterostomy versus cholecystenterostomy.* Closure of the upper end of the transected common duct, prior to cholecystgastrostomy or enterostomy is not without hazard. Ligatures have slipped or fallen away because of necrosis with escape of bile into the peritoneal cavity and bile peritonitis, or with production of an external biliary fistula. In case there is obstruction in the lower common duct, the latter is dilated and this facilitates its anastomosis with bowel.

A cholechoanastomosis therefore obviates the possibilities of bile leakage at one site, with possible fatal complications, and for this reason is preferable to employment of the gall bladder for anastomosis to the stomach or bowel.

*Implantation of pancreatic duct into bowel.* Several instances of the successful implantation of the transected portion of the pancreas into the jejunum have been reported. This is an added step in the operation and thus increases the time required for the procedure. Since, normally, pancreatic juice is poured into the intestines it would seem desirable to facilitate this. Evidence to date indicates that some patients get along very well without pancreatic juice secreted into the alimentary canal, absorb normal quantities of fat and have normal stools, others get along well but have large bulky, pasty, foul, light colored stools and absorb less fat than normal, still others tend to steatorrhea and absorb little fat (2).

The successful anatomic implantation of the pancreatic stump into bowel in man has not yet been demonstrated to afford normal or appreciable secretion of pancreatic juice into the bowel. Necropsy findings in such patients after pancreatoduodenectomy have not yet

TABLE I — SUMMARY OF 8 CASES OF ONE STAGE PANCREATODUODENECTOMY

Patient No Age	Diagnosis	Date of operation	Course
1 Lat (213868) 58 yrs	Carcinoma head of pancreas	2-2-39	Immediate reaction satisfac- tory. Died 4th day. No necropsy.
2 Th (248815) 71 yrs	Carcinoma, head of pancreas	9-26-40	Died 3d day. Necropsy bilateral aspiration bronchopneumonia.
3 Fl (32544) 57 yrs	Carcinoma head of pancreas	6-19-42	Died 5 months 3 weeks after operation. Necropsy car- cinomatosis. Following operation icterus cleared and there was gain in weight for 3½ months.
4 Weh (287625) 46 yrs	Carcinoma of ampulla invading common duct and head of pancreas	7-6-42	Steatorrhea before operation. Normal stools 10 days after operation and continuing well. Gained 25 pounds. Alive, well and working 16 months after operation.
5 Bl (290018) 54 yrs	Carcinoma, ampulla of Vater in- vading head of pancreas	8-13-42	Died 8 days after operation — uremia without anuria. Necropsy revealed no peri- tonitis or leakages.
6 He (289720) 35 yrs	Carcinoma head of pancreas	8-1-42	Died 5 months after opera- tion. Necropsy carcino- matosis. Following opera- tion icterus cleared and slight gain in weight for 2 months.
7 Las (306550) 73 yrs	Carcinoma head of pancreas ulcerating into duo- denum	4-12-43	Died 8th day. Marked as- thenia and hypoproteinae- mia (17.3 gm %). No necropsy.
8 Go (2648) 55 yrs	Large fun- gating car- cinoma ampulla with reg- ional lymph node me- tastases	5-17-43	Living and well 6 months after operation. Icterus cleared. Pancreatic fistula closed. Back at work (bookbinder).

been published to show adequate patency of the reimplanted pancreatic ducts. The report by Jung and Henriot on the completely cicatrized and impervious pancreatic stump after its implantation into jejunum for the eradication of a persistent pancreatic fistula following drainage of a pancreatic cyst, raises the question of whether appreciable pancreatic secretion may obtain after such implantations. It is possible that occluding cicatrization is the normal result of such operations. If this is true the implantation for restitution of external secretion is not justified. The writer continues to occlude the transected pancreatic stumps until evidence is presented that external pancreatic secretion may be restored by implantation procedures.

Another reason for implantation of the transected stump is that it may obviate the development of a pancreatic fistula. This would appear to the author as the best reason offered to date for such a step. Troublesome pancreatic fistulas did not occur in the series of patients presented in this report. In every case a pancreatic fistula did manifest itself several days after operation but in the survivals it closed after several weeks. In no instance was there appreciable digestion of abdominal wall.

**Repair of torn superior mesenteric and portal veins.** The neck of the pancreas is in intimate contact with the superior mesenteric vein and just superior and to the left of it is the beginning of the portal vein formed by the union of splenic and superior mesenteric veins. In large carcinomas of the head of the pancreas adhesions of the neck to the superior mesenteric vein or adhesions of the enlarged head to the first portion of the portal vein may be such that in dissection of tissue from these vessels the latter may be opened. In the writer's experience this occurred on three occasions, once in a patient (Case 6) reported in this series. Control of hemorrhage and repair of the injury was successfully carried out as follows:

Firm upward pressure is exerted on the torn vessel by the left index finger inserted into the foramen of Winslow or beneath the superior mesenteric vein. This compresses the veins into a band. After the blood is sponged away the opening in the vessel is identified and small straight hemostats are applied closely, and usually in a linear fashion to close the tear. The finger is removed and the vessel again fills with blood. None should escape if the opening has been completely closed. The compressing finger is reinserted to collapse the vein. An interrupted suture of fine silk on an atraumatic needle is inserted through the vessel wall just beneath the tip of the first hemostat. As the knot is tied, the hemostat is removed. The same step is repeated for each hemostat in order from above downward.

The high immediate mortality and the grave prognosis for those surviving the operation should not deter continued surgical attack upon this group of neoplasms. Pack and Livingstone cite the years of persistent effort that was necessary to obtain general acceptance of

radical gastrectomy for cancer. Quoting from them:

I 905 Frieden<sup>1</sup> still reported 1000 cases of gastric cancer from the surgical literature with the results obtained in their care. Two hundred and sixty-six of these patients were subjected to operation. In 538 instances the procedure was a simple exploration and closure. There were but nine resections. Only one patient survived for one year and a half. All died of the disease. That is to say not one patient of 1000 received gastrectomy, not but one in the thousand lived for as long as one and one-half years. These are the results ten to fifteen years after the work of Billroth, and about midpoint from 1883 to the present.

While gastric cancer is much more frequently encountered than carcinoma of the head of the pancreas, a more general and widespread realization of the possibilities of surgical attack upon the latter is to be envisaged as a result of persistent and concerted effort.

#### SUMMARY

1. Eight instances of one stage pancreaticoduodenectomy for carcinoma are recorded. The one stage operation should be performed unless the patient is markedly debilitated when simply a biliary shortcircuiting procedure (choleodochojunostomy) should be done as the first stage.

2. Choleodochoenterostomy is preferred to cholecystogastrostomy or enterostomy since reopening of the closed common duct has occurred leading to fatal complications where cholecystanastomoses have been performed.

3. Reimplantation of transected pancreas has not yet been justified on the basis of affording return of pancreatic secretion to the alimentary tract. However its justification as a method to avoid postoperative pancreatic fistula may be substantiated by further experience until in addition evidence is obtained that external pancreatic secretion is effectively re-established by this means.

#### REFERENCES

1. BERNARDINI, A. The Surgery of Pancreatic Tumors. St. Louis, M. C. V. Mosby Co., 1934.
2. BREWSTER, A. C. and ALLY, J. G. Proc. Soc. Exp. Biol., N. Y., 1943, 35: 43-47.
3. JONES, A. and SAWYER, J. Rev. Clin. Path. 1934, 33: 304-306.
4. PACK, G. and LIVINGSTONE, E. Treatment of Cancer and Allied Diseases, Vol. 1, p. 10. New York: Paul C. Hoeber, 1940.
5. WINTER, A. O. N. England J. M. 1941, 36: 55-57.



bladder." More recently Hess has described an intracystic type of reimplantation applicable to but few selected cases of low ureteral stricture. Practically all authors stress the importance of an extraperitoneal approach (for fear of leakage), the minimizing of infection, the avoidance of tension, and the advisability of placing the bladder at rest by suprapubic or urethral drainage.

Considerable experimental work has been done on dogs, a review of which is not necessary now. The conditions are quite different from those in man. The bladder in dogs is an intraperitoneal organ, hence the operation must be intraperitoneal; the musculature is relatively much thicker and the bladder must be closed and the wound sutured tight; hence the bladder is not put at rest. Some observations of Vermooten and associates are pertinent to this discussion. They tried oblique transplantation of the ureter by Coffey's ureterointestinal technique, incising the bladder musculature, placing the ureter in the submucous trough and carrying it through the bladder mucosa at the distal end of the trough, then suturing the muscle over the trough. Three animals thus operated upon died of peritonitis. Then a series of experiments utilized the same principle of oblique implantation by carrying the ureter through a direct opening and laying it in a trough on the inside of the bladder by incising the bladder mucosa and finally sewing the mucosa over the ureter, the end of which entered the bladder lumen at the distal end of the trough. This was much more satisfactory. Then a series of 10 dogs had one ureter reimplanted by this technique and the other by direct implantation. The comparison of late results was definitely in favor of the oblique entrance. Another observation of these authors indicated the possibility of ureteral dilation in certain instances due to infection without any demonstrable obstruction to the ureter.

In our laboratories a small number of dogs (8) have had the ureters reimplanted in the bladder by several techniques. Unfortunately the pressure of other work interfered with planned experiments. The number in each group operated upon is too small to permit conclusive deductions, and references will be brief.

In 1 dog a bilateral simultaneous reimplantation of the ureters to the bladder through an oblique canal was carried out in an adaptation of the Coffey I method of ureterointestinal anastomosis, vitallium tubes being used in the submucous channel. Two weeks later the blood urea nitrogen was normal (11.5). The animal was sacrificed 2½ months after operation. The vitallium tubes were lying free in the bladder with no incrustation, and both ureters were slightly dilated and slightly thickened. This type of experiment possessed no clear advantage and was not repeated.

In 3 dogs one ureter only was implanted into the bladder by the same method, the vitallium tube being omitted. In a 4th animal both ureters were similarly implanted with an interval of 2 weeks between operations. All dogs were sacrificed for necropsy: 2 after a few months and 2 after 11 months. All transplants were satisfactory and all 5 ureters and renal pelvis showed no dilation. These few experiences were certainly favorable for the Coffey I method of transplantations into the bladder.

We questioned whether it was necessary to incise the bladder muscle to make a channel and 3 animals were operated upon by the method which will be described as used by us on human patients, the submucous channel being made by blunt dissection. The 1st animal died of peritonitis. The 2d was in poor nutritional state and died 3 weeks after operation badly emaciated. Autopsy disclosed no specific cause of death; the anastomosis was satisfactory and the ureter was not dilated. The 3d experiment of this group is perhaps worth more comment. We were particularly desirous of learning just what happened to ureteral flaps fastened over bladder mucosa. This 3d dog had both ureters reimplanted with 4 weeks intervening between operations. A month later the blood urea nitrogen was normal and excretory pyelograms showed normal pelvis and ureters. The animal was sacrificed 4 weeks after the last operation and both ureters and pelvis were found normal in size. It was interesting to note that the ureteral flaps fastened over the bladder mucosa at the first operation were now tiny nodules

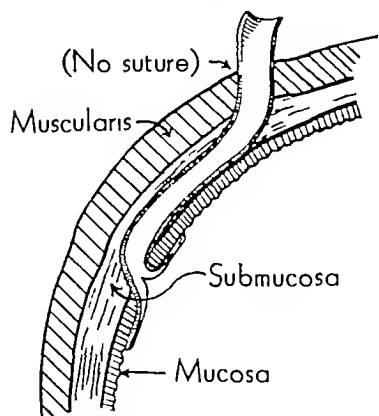


Fig 1 Diagram of method of reimplantation of ureter into bladder

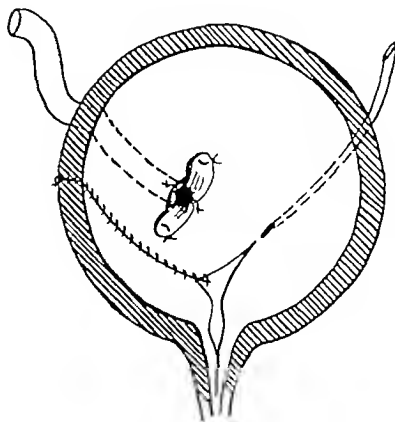


Fig 2 Diagram of intravesical view of ureteral reimplantation, following bladder resection

covered with mucosa directly connected with the bladder membrane, and a similar condition with larger nodules was found on the other side. Microscopically one noted the continuity of epithelium between ureter and bladder, with no clear line of demarcation, and indeed no abnormal fibrous tissue was seen about the junction.

In 1933, reporting a series of 41 patients, nearly 75 per cent of whom had bladder resection for carcinoma, the late Edwin Beer forcefully drew attention to the value and importance of reimplantation of the ureter to the bladder in certain cases. He quoted various authors, especially among the French, who had expressed very pessimistic views. In the same clinic, Hyman and Leiter, by 1940, had increased the series to 60 cases. No attempt was made by them to produce an oblique or valvular implantation, the end of the ureter inside the bladder was sutured to the bladder, and the ureteral wall was further anchored to the bladder wall as it entered, by two sutures. Of 27 cases controlled by excretory pyelograms, 44.4 per cent had good results, 26.0 per cent fair functional results, and 29.5 per cent were classed as poor functional results. Of 11 patients having postoperative cystograms, 8 had no reflux up the ureter operated upon, 2 had reflux up the opposite side, and 1 had reflux up both sides.

Just skepticism was expressed of many reports which were made before the days of excretory urography. Many of the kidneys

involved may have become functionless. Yet some of the earlier apparently successful cases were substantiated by chromoscopy and even ureteral catheterization, which demonstrated good renal formation. But there was no way to estimate the anatomical result. Now excretory urography affords at once an answer to both queries.

Realizing that obstruction is a large factor in vitiating results, and that infection also plays a major rôle, we have been trying a simple technique during the past 3½ years, applying many of the principles mentioned. The operation is always extraperitoneal. Drains are so placed that only rubber tissue contacts the tissues to diminish fibrous tissue formation, and the drains are removed early. Tension is avoided. Sutures are used only inside the bladder and penetrate mucosa and submucosa only, and the bladder has been kept at rest by suprapubic drainage. Fine chromic sutures—No 0000—are used, and we have noted no deleterious results from having the knots within the bladder. Sulfadiazine is used to control infection. In 2 cases we used one suture outside the bladder, placed in the peri-ureteral tissue, but otherwise none was employed in this situation as it seems probable that suturing of the ureteral wall would encourage the formation of fibrous tissue and might also interfere with intrinsic blood supply.

The operation (Figs 1 and 2) is done as follows. A small incision is made at the appro-



Fig. 3. Roentgenograms, Case G. H. 49 years of age, right ureter showing view before operation, 6 weeks after operation, and 1 year after operation.

prate place on the bladder wall, penetrating muscle only. A rather pointed curved clamp bluntly dissects a channel under the mucosa downward toward the bladder outlet for about 2 centimeters. A small incision is made through the mucosa over the end of the clamp. Working through a suprapubic bladder opening another clamp is passed retrograde through this channel, and grasps the ureter the distal centimeter of which has been bisected, forming a "fish-mouth." The ureter is drawn into the bladder through this submucous channel, and the two ends are each fastened to the bladder mucosa and submucosal tissues by a suture of No. 0000 chromic catgut. Finally at each of the two angles between the ureteral flaps, a similar suture is placed through the mucosa and submucosa of the ureter and bladder and care is used to avoid the muscular layers. No other sutures are placed. This affords enough fixation if the ureter is under no tension. No catheter is placed in the ureter. A cigarette drain with no gauze exposed is placed near the junction of the ureter and the bladder but the withdrawal of this is begun the day after operation.

Brief protocols of the 10 patients upon whom this operation was performed, are given. One patient apparently doing well, died suddenly the night of operation; no autopsy was obtained. There were no urinary fistula and no abscess in any patient. All ureters functioned well. Nine patients had resection of

the bladder for carcinoma, and one for long standing fibrous obstruction at the lower end of the ureter. Photographs of the excretory pyelograms of the 9 surviving patients are shown—before operation about 3 or 4 weeks after operation and (in all but 1) 3 months or more after operation. The earlier postoperative films all indicated some ureteral dilation, but the late ones (8 cases) were of more interest and value. Of 3 patients with some preoperative ureteral or pelvic dilation or both 2 presented the same condition after operation and 1 showed increased dilation possibly due to recurrent neoplasm. Of the 6 patients with no preoperative dilation 1 had no late pyelogram. 3 showed no dilation in the later postoperative films, showed very slight dilation and the 5th had evident hydroureter and hydronephrosis as late as 8 months after operation but none 16 months after operation. This man (Case 6) entered the hospital later with a bladder papilloma adjoining the prostatic border anteriorly but with no evidence of growth about the new ureteral opening on rectal palpation or by cystoscopy.

Function of the kidney associated with the reimplanted ureter as indicated by the excretion of diodrast in 5 minute films, was as good or better than it was before operation in all cases. There were no postoperative symptoms or abnormal signs in the kidney except for one attack of possible mild pyelonephritis in Case 2.

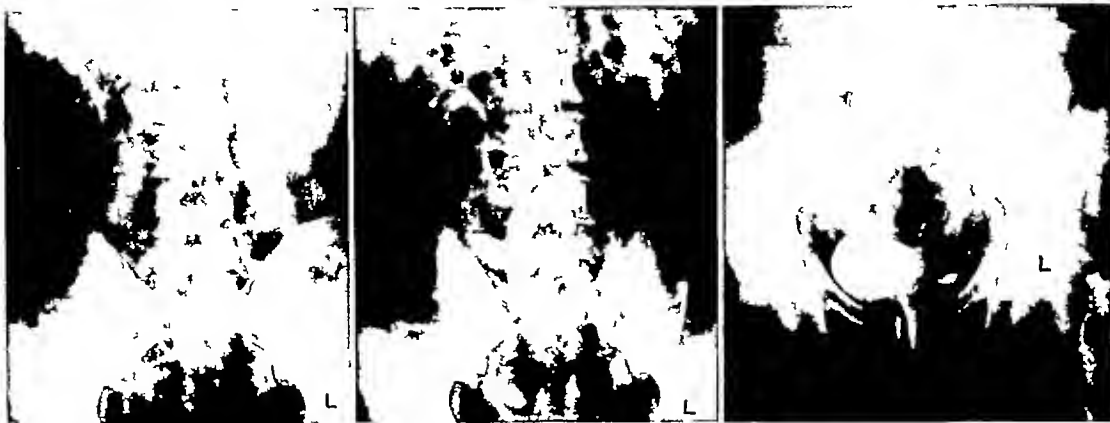


Fig 4 Roentgenograms, Case 2, G D, 64 years of age, left ureter, showing views before operation, 27 days after operation and a cystogram 30 days after operation

We have postoperative cystograms on only 4 patients. Patient in Case 10 who had a long standing ureteral dilation and thickening due to fibrous obstruction, and who had no postoperative improvement in this regard (although the pain symptom was relieved) showed slight reflux 8 months after operation. Patient in Case 2 showed reflux a few weeks after operation (rather early observation). Patient in Case 7 showed no reflux 15 months after operation, and in Case 6 had none 16 months after operation.

#### CASE REPORTS

**CASE 1** G H, No 244,004, a 49 year old male, was admitted in January, 1940, with transitional cell carcinoma of the bladder. Resection of the bladder was carried out with reimplantation of the right ureter by the technique here described. After operation the wound was infected, and a secondary closure of the cystostomy was carried out. The right upper urinary tract functioned well and has caused no symptoms in the ensuing 3 years. There was no evidence of recurrence of the neoplasm and cystoscopy showed a normal bladder wall after 3½ years. A normal excretory urogram was obtained after 1 year.

**CASE 2** G D, No 302,795, a 64 year old male, with recurrent bladder carcinoma was admitted to the hospital in July, 1941, after radium treatment elsewhere through a cystostomy wound. The patient was a diabetic. A bladder resection with reimplantation of the left ureter was carried out by the technique described. The pathologist's report was "papillary transitional cell carcinoma of the bladder." The postoperative course was satisfactory. The cystostomy tube was removed on the 13th day. Patient was discharged with a dry wound on the 34th postoperative day. Follow-up examinations were

not carried out by us as the patient returned to his home in Haiti. He died 8 months later, apparently of carcinoma. Postoperative cystogram showed reflux up transplanted ureter 4 weeks after operation. The excretory urogram showed some pelvic dilation 27 days after operation.

**CASE 3** G M, No 309,716, a 53 year old male, was admitted to the hospital in October, 1941, with a carcinoma of the bladder, about the size of a dime and adjoining the left ureteral orifice. Mild left hydronephrosis and hydroureter were present. Bladder resection with reimplantation of the left ureter was performed by the procedure described. The pathological diagnosis was "transitional cell carcinoma," and the tumor was found to have invaded the lower portion of the ureter. The postoperative course was uneventful except that the cystostomy closed slowly because of mild obstruction from an enlarged prostate. Patient was readmitted 3 months later, and a single cyst of the right kidney was partially excised. Urinalysis at this time was normal. There were no symptoms referable to the left upper tract. Pyelograms up to that time showed a moderately hydronephrotic left upper urinary tract. Regular cystoscopic follow-up examinations were made and 1 year from the time of the original operation a recurrence was found. Subsequently the patient developed carcinomatosis. Ureterointestinal transplantation and thoracic chordotomy were done with some palliation. We feel certain that the eventual disappearance of function of the left side was due to the massive tumor recurrence.

**CASE 4** P L, No 311,423, a 62 year old male, was admitted to the hospital in October, 1941, with a transitional cell carcinoma of the bladder near the right ureteral orifice. A bladder resection with reimplantation of the right ureter was carried out by the method described. His postoperative course was satisfactory though the cystostomy healed slowly. A course of sulfadiazine was given. Patient was discharged in good condition on the 49th postoperative



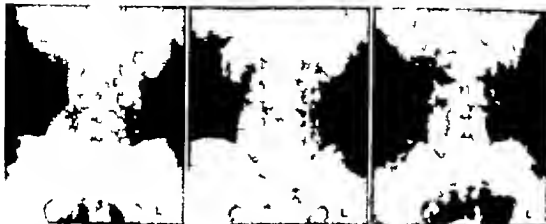


Fig. 5. Roentgenograms, Case 3, G. M., 41 years of age, left ureter showing views before and 27 and 77 days after operation.

day. He has had occasional pain in the right flank, never lasting over a few hours. The last urine examination found 25 white blood cells per high power field in a centrifuged specimen. Two papillomas were fulgurated cystoscopically a year after operation. Excretory urograms demonstrated slight dilation of the right pelvis, 43 months after operation.

**CASE 5.** F. C., No. 3, 45, a 47 year old male, was admitted to the hospital in October, 94, with bladder tumor. Complete study found the patient in good condition except for the lesion on the left ureteral orifice. Under general anesthesia, bladder resection and reimplantation of the left ureter were carried out as by the method outlined. The specimen removed measured 6 by 4 by 2.5 centimeters. The pathological diagnosis was transitional-cell

carcinoma of the bladder. Approximately 4 hours after operation the patient, as conscious and apparently in good condition when he suddenly became cyanotic and expired within 5 minutes. A autopsy was not performed. Death probably as due to massive pulmonary embolism. There seems to be no reason to believe that the specific technique of the reimplantation had any connection with the fatal outcome. The ureter as not dilated before operation.

**CASE 6.** J. M., No. 3, 9009, a 4 year old male was admitted to the hospital in February, 94, with transitional cell carcinoma of the bladder near the left ureteral orifice. Bladder resection with reimplantation of the left ureter as carried out, except for nonspecific postoperative epididymitis, the postoperative course was entirely satisfactory. Pa-

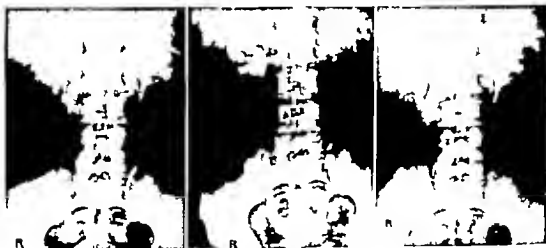


Fig. 6. Roentgenograms, Case 4, P. L., aged 6 years, right ureter showing views before operation and 20 days and 4 months after operation.

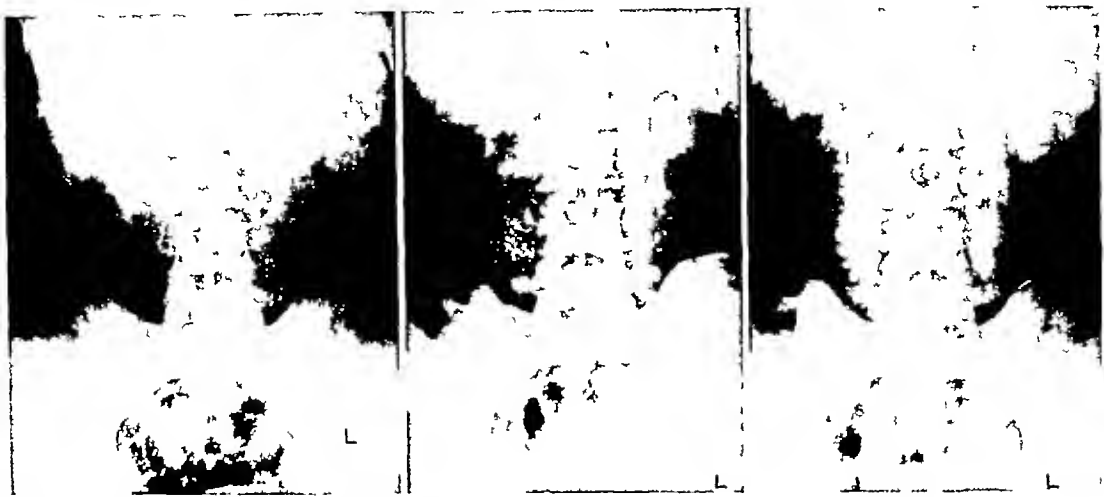


Fig 7 Roentgenograms, Case 6, F M, 53 years of age, left ureter, showing views before operation and 12 days, and 8 and 16 months after operation

tient was discharged in good condition with wound healed on the 27th postoperative day. Subsequently recurrent papillomas have been fulgurated cystoscopically. Seven months after operation intravenous indigocarmine appeared in 3 minutes from the right ureteral orifice and in 5 minutes from the left neostomy. Excretory urograms show moderate pelvic dilation 8 months after operation—cause undetermined. Sixteen months after operation the excretory pyelogram is within normal limits. At a subsequent cystotomy, the neostomy was easily catheterized and could clearly be seen to pass obliquely through the bladder wall. A cystogram found no ureteral reflux.

CASE 7 F M, No 76,006, a 54 year old male, was admitted to the hospital in January, 1942, complaining of terminal hematuria of 4½ months' duration. Cystoscopy revealed a slightly raised, flat surfaced, ulcerated lesion approximately 3 centimeters from the right ureteral orifice. Biopsy was reported as "epidermoid carcinoma of the bladder." Complete investigation found no other abnormalities. A bladder resection was done, and a piece of tissue 6 by 4 by 1 centimeter was removed. In the center of this mass the lesion was found to be 1.5 by 1 centimeters. The muscle, however, was not invaded. The pathological report on the operative specimen was "transitional cell carcinoma of the bladder." The right ureter was reimplanted into the bladder by the technique here described. Except for temperature elevation (due to a mild bronchopneumonia) the first 3 days, the postoperative course was uneventful. Cystostomy tube was removed on the 14th postoperative day. Patient was discharged with a dry wound on the 30th postoperative day. A course of sulfadiazine was given. Subsequent visits to the clinic have demonstrated a completely satisfactory



course. The last cystoscopy done 1 year after operation found no evidence of tumor, healing was complete, and the urine was clear. Nine months after operation indigocarmine injected intravenously appeared simultaneously from both sides, in good concentration, in 2 minutes. Cystogram demonstrated no ureteral reflux. Excretory pyelograms show no dilation of the side operated upon.

CASE 8 R V, No 318,025, a 30 year old male, was admitted to the hospital in February, 1942, with a large papillary tumor of the bladder between the left ureteral orifice and the bladder outlet. Total cystectomy was refused at this time. A bladder resection with reimplantation of the left ureter into the bladder was carried out by the technique described. Subsequently radon seeds were implanted in the suture line. Eventually recurrences were found. Later bilateral ureterointestinal transplantation and total cystectomy were done and the patient has



Fig. 8. Roentgenograms, Case 7. F. M., aged 54 years, right ureter showing views before operation and 45 days and 7 1/2 months after operation.

returned to work. The reimplantation of the left ureter following resection of the bladder was satisfactory and patient never had symptoms referable to this. Intravenous pyelograms demonstrate the good anatomical result.

CASE 9. F. A. No. 33545. 55 year old male, was admitted to the hospital in August, 1942, with an epidermoid carcinoma of the bladder just over the left ureteral orifice. A bladder resection with reimplantation of the ureter was done by the technique described. Except for mild wound infection the postoperative course was satisfactory. Patient was discharged with wound healed on the 8th post

operative day. He was readmitted 4 months later

with symptoms of left pyelonephritis which promptly subsided. As can be noted in the pyelograms, the hydronephrosis had increased. A local recurrence of the tumor seemed quite likely as induration could be made out rectally in the region of the reimplantation. Cystoscopically, however, no recurrence could be made out 5 months after operation and intravenous indigo-carmines appeared in good concentration from the right ureteral orifice in 8 minutes and from the left neostomy in 9 minutes. At the time he was symptom free. Excretory urograms demonstrate marked bydronephrosis.



Fig. 9. Roentgenograms, Case 9. F. A., 55 years of age, left ureter showing views before and 45 days and 7 1/2 months after operation.



Fig 10 Roentgenograms, Case 9, F A, 52 years of age, left ureter, showing views before operation and 13 days and 4 months after operation

CASE 10 R R, No 251,771, a 39 year old female, was admitted to the hospital in August, 1942, with pain in the right flank, for surgical treatment of right hydronephrosis and hydroureter. Ureteral meatotomy and dilations had been given a thorough trial without effect. At operation considerable heavy fibrous tissue was found about the ureterovesical juncture which seemed to cause the obstruction by constricting the ureter. The ureter generally was thickened and fibrous. Reimplantation of the dilated ureter was done. The postoperative course was satisfactory and patient was discharged on the 31st day after operation without pain, in good condition,

and with wound healed. Seven months after operation there were normal urinalysis and marked symptomatic relief, although occasional mild right flank pain was reported. She had gained 22 pounds. The pyelograms show but little improvement. The normal urinalysis after 3 months without drugs is clear evidence of improvement, as we had had evidence of persistent pyuria for 4 months before operation.

#### RÉSUMÉ

The value of reimplantation of the ureter in the bladder is generally recognized. The type



Fig 11 Roentgenograms, Case 10, R R, 39 years of age, right ureter, showing views before operation and 10 weeks and 9 months after operation

of cases in which it is employed and the various methods advised are discussed.

Some experimental work is referred to including a few applications to dogs of the operation here described for man.

The details of that operation are given with brief protocols of 10 patients. Nine of these had carcinoma of the bladder and 1 had low fibrous ureteral obstruction. Urograms before and after operation demonstrate little or no dilation of the upper tract following operation in 5 patients having normal urograms before operation. Ureters dilated before operation have remained so afterward. Increased ureteral dilation as noted in the late postoperative pyelogram was seen but once (Case 9) and this patient probably had local recurrence of carcinoma. There were no perivesical abscesses or fistulas.

In all patients, function of the kidney on the

side operated upon, as demonstrated in the 5 minute films of the excretory urogram series, was as good after operation as before or better.

Postoperative cystograms in 4 cases show no ureteral reflux in 2 instances, some months after operation, slight reflux in 1 patient who had had a dilated and thickened ureter above a fibrous obstruction, 8 months after operation, and definite reflux a few weeks after operation in the 4th case.

#### REFERENCES

1. B. FR., L. Am. J. Surg. 93, 20, 5-17.
2. FERNANDEZ, H. D. Surg. Gyn. Obst. 93, 7, 139-144.
3. HARRIS, E. J. Urol. 34, 26, 866-877.
4. LITTELL, A. and LITTELL, H. E. Surg. Clin. N. America, 34, 20, 343-349.
5. P. STONE, J. F. J. Urol. 93, 4, 10-13.
6. TOUTER, W. H. T. Brit. Ass. Genitourin. Surgeons, 93, 3, 57-60.
7. A. KROODER, V. SMITH, J. W. NATHAN, AGER, C. H. J. Urol. 93, 5, 767-769.





Fig. 2. New type of bone plate. Top view showing oval slots for screws.

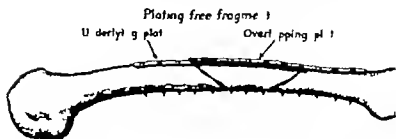


Fig. 3. Drawing illustrates how plates may be stacked and staggered lengthwise to form continuous metal truss forming all three fragments into one solid unit.

ately accomplished without loss of position by exerting firm pressure on the distal end of the distal fragment.

4. The corrugated shape adds considerably to the strength of the metal. The alternate ridges allow two or more plates to be stacked nested or laminated one on the other in

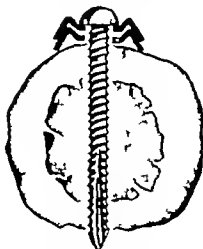


Fig. 3. Cross section drawing of bone illustrating how plates can be stacked one on the other. Screw is in oval slot and holding plates firmly to bone. Note that only the legs of the lower plate touch the bone allowing space for callus to grow under plate. The drawing also shows cross section of the plate which is roughly M shaped.

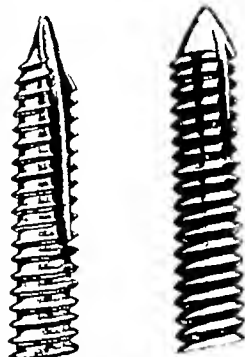


Fig. 4. Enlarged photograph of screw designed by authors, left, and conventional type bone screw, right. The screw at left has long sharp flut with offset point forming perfect tap which cuts deep even threads beginning with the first turn. The screw at right catches on the first few turns but does not cut even threads in the bone and it lacks the holding power of the authors' screw.

creasing the actual thickness only by the gauge of the metal itself, by 0.07 centimeter per plate. The stacking of plates also provides a form of leaf spring action (Fig. 3).

In addition to stacking, the corrugated shape permits lengthwise staggering of the plates. The importance of this is illustrated by the following problem. Let us assume we are confronted by a double fracture of the femoral shaft, one fracture being in the upper third, the other in the lower third. In dealing with this condition it would be necessary to use two conventional plates—one bridging the lower which would, in turn, make a point of weakness at the middle fragment or where the two independent plates tend to contact each other. By utilizing corrugated shaped plates one can take advantage of their ability to be staggered lengthwise and thereby form a continuous truss of metal from the upper across the middle and to the lower fragment. The weak point at the middle fragment is thus removed (Fig. 2).

On the femur 2 or more plates (2 for a single fracture) are recommended. Six screws are used for fixation. For the tibia and the humerus 1 plate, held in place by 4 or 6 screws, is adequate. However, in our opinion, 4 of the tuk-tap screws will hold sufficiently in tibial and humeral plating jobs. Whenever possible the fracture site should also be trans-fixed by a screw. Of the various screws we have found the 6-20 (18-8) stainless steel tuk-tap type to be the most satisfactory. This screw has a sharp off-center point, a long, single flute and contains 20 threads to the inch (Fig. 4). The off-center point allows for cutting the bone threads on the first turn of the screw. This type of tap facilitates the passage of the screw through the bone with approximately 40 per cent less force than is usually required by the older type bone screws. In-

stead of using a No. 32 drill for the preliminary drilling, we find the smaller No. 36 drill will provide a more perfect fit. This smaller drill hole permits a greater bone to metal ratio and a consequent increase in holding power. Other screws call for the larger No. 32 drill. The 6-20 tuk-tap screws we employ contain the same ratio of alloys as does the plate. We have found the holding power of the 6-20 tuk-tap screw to be approximately 46 per cent greater than the Sherman 6-32 screw. This holding power comparison between the 6-20 stainless steel and the Sherman screw is also borne out by the experimental work of W. F. Lyon (5, 6).

The plates and screws described have been devised for the larger bones. For the bones of the forearm a plate of the same design but of smaller dimensions is employed. For the small plate a 4-24 stainless steel screw has been found to serve adequately the purpose of fixation.

These plates and screws have been used in more than 70 cases of fractures of the long bones since September 1, 1940. The majority of the patients were operated upon at the Los Angeles General Hospital. In addition to this series Joldersma reports 32 cases in which he used this form of internal fixation.

#### SUMMARY

A new type of bone plates and screws is presented and advantages of each described.

#### REFERENCES

1. HAWLEY, G. W., and PADULA, R. D. *J. Bone Surg.*, 1938, 20, 469.
2. JOLDERSMA, R. D. *Am. J. Surg.*, 1943, 60, 51.
3. LANE, W. A. *Operative Treatment of Fractures*. London: London Medical Publishing Co., Ltd., 1905.
4. Idem. *Brit. M. J.*, 1905, 2, 1325.
5. LYON, W. F. Personal communication.
6. LYON, W. F., COCHRAN, J. R., and SMITH, L. *Ann. Surg.*, 1941, 114, 373.
7. SOUTTAR, H. S. *Ann. Surg.*, 1913, 58, 653.



# THE TREATMENT OF INTERTROCHANTERIC FRACTURES OF THE FEMUR WITH A HANGING CAST

MITCHELL D. JOHNSON, M.D., St. Louis, Missouri

**I**n an analysis of the causes of death in patients with intertrochanteric fractures of the femur at St. Louis City Hospital, Leydig and Brookes (2) found pneumonia to be the cause in from 39 to 53.4 per cent of the fatal cases. Decubitus ulcers have always been a major problem in the care of these patients. To overcome some of these complications, the use of a hanging cast has been tried. Up to the present time over 50 cases have been treated by this method. In this series, the mortality rate has been reduced from 39.3 to 18 per cent, and the duration of hospitalization reduced from 84.7 days to 62.3 days (Table I).

The first casts used were ordinary, padded midthigh casts. It was soon learned, however, that if enough weight was attached to a cast for reduction of the fracture, pressure sores

From the Department of Surgery, St. Louis City Hospital.

TABLE I.—COMPARISON OF HANGING CAST AND OTHER TREATMENT

	Hanging cast of treatment	Other forms of treatment
Number of cases	50	30
Average age in years	70.6	63
Average age patients expired in years	79.6	74
Average hospital days	62.3	84.7
Mortality per cent	18	30.3

were found on the leg in 39.4 per cent of the cases, and of these, 16.9 per cent had a foot drop when the cast was removed. Skin-tight casts were then tried and were found to be as ineffective in preventing pressure sores as the padded casts. Dr. J. A. Key suggested that a Steinmann pin inserted through the distal end of the femur and incorporated in the cast might prevent the pressure sores and peroneal nerve paralysis with accompanying foot drop. The use of such skeletal traction has eliminated the complications mentioned. No local infections of the soft tissues or bone injury has resulted from the use of the Steinmann pins.

The hanging cast is applied in the following manner. The patient is given a sedative either a barbiturate or morphine sulfate. A Steinmann pin is then inserted through the lower end of the femur under local anesthesia. Stockinet and sheet wadding are applied in the usual manner from the midthigh region down to, and including the foot. Felt padding is applied over the bony prominences. An ordinary midthigh cast is then applied incorporating the Steinmann pin in the cast. The thickness of the cast is varied with the size and condition of the patient. A frail woman of 80 years would receive as light a cast as possible, whereas a man of 50 years would get a much heavier one.

The cast is applied with the knee in 30 to 40 degrees of flexion, and plaster loops made from narrow plaster slabs are incorporated in the cast at the knee and at the foot (Fig. 1). The loops, which serve as a means of attach-



Fig. 1. 75 year old man with an intertrochanteric fracture in right femur on the 3d day after injury. Note that the footpiece of the cast has been turned up allowing the cast to hang free.

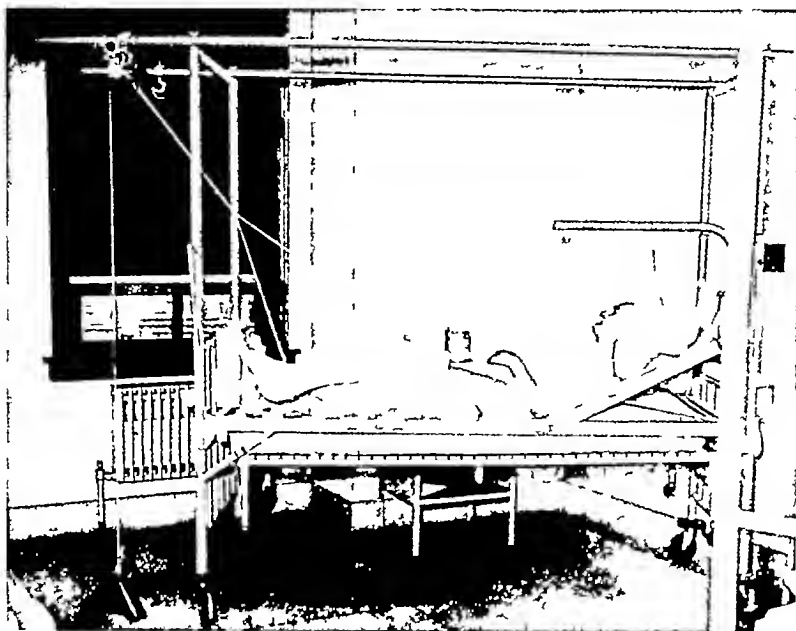


Fig 2 Same patient as in Figure 1 in bed with traction applied through the cast.



Fig 3 a, X-ray film of intertrochanteric fracture of the femur as patient entered the hospital on the day of the accident, before the application of a hanging cast. b, Same patient after 17 days of treatment in a hanging cast. c, X

ray film showing callus formation which was present when the cast was removed on the 44th day. Patient was discharged from the hospital on crutches on the 49th day after admission.

ing ropes to the cast for traction, are placed on the anterolateral aspect of the cast, so that when traction is applied, the external rotation of the leg is corrected (Fig 2). As soon as the plaster is sufficiently hardened to stand the strain, ropes are tied to the loops, and from 20 to 35 pounds of traction is applied to the cast through an overhead pulley at the foot of

the bed. The line of traction is similar to that used in a Hodgen splint. The pulley can be moved so as to obtain as much abduction of the femur as desired. A folded pillow is placed beneath the cast at the knee for support. The traction is used only while the patient is in bed (Fig 2), the weight of the cast acting as traction while the patient is in a wheel chair or up



Fig. 4. a, Comminuted trochanteric and subtrochanteric fracture of the femur seen by roentgenogram on admission to the hospital with temporary splint applied by an ambulance driver. b, Same patient after 4 days' treatment in hanging cast. c, Same patient 4 weeks after admission, showing bony callus formation. Cast was on for total of 46 days, the patient leaving the hospital on crutches 5 days after admission.

on crutches. It was found that a permanent loop tied at the junction of the cast rope and the traction rope minimized the amount of adjusting necessary and made it possible to entrust an attendant with returning a patient to his bed without supervision.

One to 3 days after the application of the cast, each patient is placed in a wheel chair for a period of 2 to 6 hours daily. One pillow is placed in the wheel chair beneath the patient and another under the cast. The footboard on the side of the affected extremity is turned up so that the leg hangs without support. With the patient using the overhead bar for support, he can usually be moved by one attendant. If gentle traction is applied to the cast as the patient is placed in the wheel chair and if no pressure is applied over the fracture site the pain is minimal. Elderly patients are kept upright in the wheel chair by means of a folded sheet passed about the waist and tied to the back of the chair. No patient has refused to be up in a wheel chair because of pain.

If he is able, the patient is instructed to use crutches after the 3d week. The cast is permitted to hang but weight bearing on the affected extremity is not allowed.

The reductions obtained by the use of a hanging cast are similar to the reductions obtained by other forms of treatment (Fig. 3 a, b; Fig. 4, a, b). New bone is often detectable by roentgenography at the end of the 4th

week (Fig. 4 c). The casts have been removed from these patients after an average of 43.4 days (Fig. 3 c) and the patients discharged from the hospital on crutches. Weight bearing, however, is not allowed until the 10th or 12th week. Follow-up of these patients reveals no shortening or deformity not present when patients were discharged from hospital.

#### SUMMARY

1. Fifty cases of intertrochanteric fracture of the femur have been treated by the hanging cast method.
2. The mortality rate for intertrochanteric fractures has been reduced 54.2 per cent.
3. Complications, such as pneumonia, decubitus ulcers, stiffness of knees and ankles, weakness from lying in bed, etc., are less frequent as patient can get out of bed early.
4. The reductions have been as good as the reductions obtained by other methods.
5. The time required for the formation of new bone and consequently the duration of hospitalization have been reduced.
6. The hanging cast is technically a simple method of treatment.
7. No instances of nonunion have occurred.

#### REFERENCES

- LEITCH, S. NLEY M. J. *Minnesota M. Ass.* October 1930, pp. 43-44.  
 LEITCH, S. NLEY M. BROOKS, THOMAS P. J. *Missouri M. Ass.* August, 1940, pp. 354-357.



emergency surgery of the kidney unless there are signs of internal hemorrhage. When blood is present cystoscopy or safer and simpler an air cystogram will be valuable. When intraperitoneal hemorrhage is suspected paracentesis with an 18 gauge spinal needle is a safe and valuable procedure. In case of any doubt, however exploratory operation is justified as the risk of doing an unnecessary operation even on slight evidence is less than the danger of a delay of twelve or more hours until there are definite signs of peritonitis.

#### TREATMENT

In early cases shock is due to internal hemorrhage and can be effectually combatted only by surgical hemostasis. Mortality increases directly with the amount of hemorrhage, the mortality in the Louisville General Hospital cases being 17.2 per cent with hemorrhage of less than 500 cubic centimeters, 41.5 per cent with hemorrhage of 500 to 1000 cubic centimeters, and 64.6 per cent with hemorrhage of over 1000 cubic centimeters. Abdominal wounds stand transportation and delay poorly for this reason. They should, therefore have first priority in evacuation to the closest point where operation can be carried out. When active intraperitoneal bleeding is going on it cannot be counteracted by intravenous medication, and delay in operation to treat shock may be fatal. However immediate operation does not preclude adequate treatment for shock which can be carried on as well on the operating table as in a shock ward. Adequate replacement therapy with blood or plasma should be started at the earliest possible moment and continued before during and after operation.

Gentle expeditious surgery with the patient under suitable anesthesia will not appreciably aggravate shock particularly when adequate replacement therapy is going on. In this connection it must be emphasized that replacement preferably with blood, should equal or better exceed the estimate of blood loss. In late cases arriving at a surgical center those with large hemorrhage will have been eliminated by death and shock will be due to other causes. In such cases reasonable delay for resuscitation measures is justified.

#### ANESTHESIA

The necessity for complete exploration makes the best possible relaxation advisable. For this reason spinal anesthesia, unless contraindicated by marked hypotension is to be preferred. Local and regional anesthesia are too time consuming and do not allow adequate exposure. Gas induction followed by ether and adequate oxygen is probably the most useful general anesthesia, although intravenous anesthesia, ethylene or cyclopropane may have a place.

#### INCISION

Of the conventional incisions the long rectus splitting or long transverse incision between the costal margin and the iliac crest give the best all around exposure. Extensions at right angles to these incisions may be necessary and should be made without hesitation, rather than limit exposure. In injuries localized to one upper quadrant oblique incisions, with division or extension of the costal arch may be useful. Many thoracoabdominal wounds particularly on the left side, may be best exposed through the thorax and damage to the contents of both cavities repaired. Lower abdominal rectal and bladder injuries may be exposed through the midline.

#### EXPLORATION

When the abdomen is opened the first consideration is the control of the hemorrhage which may have been increased by respiratory or other motion during the induction of anesthesia and by the release of pressure when the abdomen is opened. At this point mechanical suction is most valuable as recognition of bleeding points is often impossible until the cavity has been cleared of clots and liquid blood. Blind clamping in a pool of blood may be disastrous and it is at this point that the surgeon unaccustomed to emergency surgery loses precious time. Digital control of large vessels is most valuable. The portal vein, hepatic artery and even the celiac axis may be compressed between the thumb and a finger inserted through the foramen of Winslow effectively halting most bleeding from the upper abdomen. The mesenteric or splenic vessels may be compressed in their course as

## GRISWOLD TRAUMATIC WOUNDS OF THE ABDOMEN

may the short renals Pressure on the iliac trunks will likewise be effective in the lower abdomen Direct control of bleeding points may now be accomplished under vision In the case of the liver, suture may be possible Temporary pressure will suffice in many instances since the bleeding is largely venous In other cases tamponade with strips of muscle from the abdominal wall may be necessary Packing with gauze should be avoided whenever possible since it is frequently followed by infection and secondary hemorrhage De-tached and devitalized portions of liver should be removed and a drain placed down to the wound to permit the escape of bile Damage to the spleen is usually treated by splenectomy, except when the wound is small and hemorrhage has stopped spontaneously Attempts at repair are usually futile and waste of both time and blood

The kidneys and their pedicles may be exposed transabdominally by incising the peritoneum lateral to ascending or descending colon and reflecting the bowel and its mesentery medially Most wounds of the kidney with active hemorrhage are best treated by nephrectomy because of the additional blood loss during repair Severe fragmentation is also an indication for removal, making sure in all cases of course that a second good kidney is present Smaller wounds in the posterior peritoneum should be sutured and the retroperitoneal spaces drained through a stab wound in the flank Following the control of hemorrhage a systematic search of the hollow viscera should be made The sequence of this examination depends upon the estimated track of the missile, and the location of the incision but no portion of the gastrointestinal tract should be neglected, as a viscus may have moved from its position at the time of injury In the upper tract particularly, attention should be paid to easily overlooked wounds of the abdominal esophagus and posterior wounds of the stomach and duodenum If present or suspected these latter may be exposed by an incision or enlargement of a wound on the anterior surface of the stomach or duodenum In other cases, exposure through the gastrocolic or gastrohepatic omentum may suffice

In both large and small intestine, hematomas in the mesentery may hide perforations in the mesenteric border The transverse portion of the colon is usually examined first if the wound is high, since it is the most accessible portion, the ascending and descending portions being left until exposed by exploration of the small bowel Systematic exploration of the small bowel without undue exposure is greatly simplified by placing a suture or Babcock forcep on the first presenting loop, reading the gut either up or down from this point to one end and then returning to the marker and going in the opposite direction until all has been examined

### REPAIR

Most lacerations of the bowel even when multiple lacerations are close together should be repaired rather than resected Simple pursestring or Lembert sutures of fine material usually suffice Occasionally the conversion of two nearby openings into one by cutting between them, makes closure easier without decreasing the lumen of the bowel too much When laceration, contusion, or destruction of blood supply makes resection necessary in the small bowel, primary anastomosis should be done In the large bowel, exteriorization with the formation of a colostomy is better The repair of wounds of the colon should be supplemented by a tube cecostomy to relieve tension Enterostomy following repair of the small bowel is not recommended, since it is not so effective as suction on an indwelling gastric or Miller-Abbott tube Few wounds of the pancreas are seen, both because of its size and coincident injury to great vessels Repair is usually futile, except for injury of the tail, when resection may be carried out The wound should be drained Wounds of the bladder should be sutured in layers and cystostomy performed or a Foley catheter inserted Small wounds of the ureter may be repaired and a drain inserted Occasionally simple drainage will suffice and the fistula will often close spontaneously Division of the ureter near the bladder may be treated by re-implantation into the bladder If higher, lumbar ureterostomy is advisable if there is loss of substance and repair is impossible Drain-

age of the urine is the primary consideration. Before closure the peritoneal cavity should be cleaned of all blood clots, bits of tissue and intestinal, biliary or urinary contents. Lavage is not only useless but harmful. Sulfanilamide or sulfadiazine should be implanted in dose of 5 to 15 grams especially near perforations. Careful abdominal closure in layers may be contraindicated by the condition of the patient. Even if this is not the case, through and through closure with heavy nonabsorbable material may be advisable because of the high incidence of postoperative evisceration. Drainage of the peritoneal cavity to prevent or treat future bacterial peritonitis is futile. However drains should be inserted to take care of leakage of urine, bile, or pancreatic fluid, when indicated. The retroperitoneal tissues should be also drained if they have been contaminated by bowel contents.

#### POSTOPERATIVE TREATMENT

The treatment of shock by intravenous administration of blood and plasma is continued as long as necessary. Replenishment of protein by this means may also be necessary

later in the convalescence. Decompression of the bowel by suction through an indwelling tube is a routine and should be instituted as early as possible to prevent tension on sutured wounds of the gastrointestinal tract and to prevent the ileus which frequently occurs. Other routine measures for the prevention of complications common to abdominal surgery are also placed in operation. Further evacuation to the rear should not be undertaken until the patient is out of shock and improving.

#### SUMMARY

Wounds of the abdomen are of the penetrating and nonpenetrating variety. The diagnosis of penetrating or perforating wounds is usually obvious. That of nonpenetrating wounds may be difficult. Any abdominal organ may be involved in the penetrating type and almost any in the nonpenetrating type. The principal cause of death in both types is hemorrhage with peritonitis as a cause of secondary importance. Delay in evacuation or operation for the treatment of shock is not justified in either type since shock is due to hemorrhage.

# OBSERVATIONS ON THE TRANSUDATE IN INTESTINAL STRANGULATION

I The Effect of Adrenal Cortical Extract on Its Toxicity  
HAROLD LAUFMAN, M D, Captain, M C, U S A, and S CHARLES FREED, M D,  
Chicago, Illinois

THE cause of the disturbances and death following interference with the blood supply to the intestine has been studied extensively for many years. Excellent summaries of various aspects of the literature will be found in the reports of Cooper, Herrin and Meek, Donaldson and associates, and Harkins. It appears that intestinal strangulation, the lethal factors associated with intestinal obstruction are superimposed upon those resulting from death of the intestinal tissue. The cause of death from strangulation of the intestines has been attributed to many factors. Most prominently considered in this connection have been the nerve reflex, the fluid loss, and the toxemic theories. The importance of nerve reflexes contributing to ill-effects and death cannot be denied, but the fact that animals succumb even when the strangulated intestine is denervated rules this out as the primary mechanism. Similarly local fluid loss and vomiting play a major rôle in cases of strangulation but the evidence is controversial, to say the least, that the amounts so lost are sufficient to explain the rapid downhill course in every instance. A large body of evidence has accumulated that some toxic material is absorbed into the blood stream in strangulation and contributes the major rôle in establishing the subsequent course and outcome. Innumerable attempts have been made to identify the toxic material and to determine the mode of its action. Acetylcholine, adenosine, histamine, and complex protein decomposition products have been implicated. The toxic

material has been obtained from the lumen, wall, and transudate of the strangulated intestine.

Our present studies have been upon the transudate from strangulated intestine of the dog, because the material it contains could more readily be considered absorbable into the blood stream than material obtained from the lumen or wall. The procedure was as follows. In the dog anesthetized with ether the inframesocolic portions of the small intestine were strangulated by tying off their blood supply, and at the same time the lumen was obliterated at both ends. This part of the intestine was completely enclosed in a rubberized bag to collect the transudate in a manner similar to the method employed by Foster and Hausler. The operation was carried out under aseptic precautions. After 4 to 6 hours the bag was released, and the transudate which had collected was emptied into a sterile container for testing. The fluid usually appeared light pink in color and turned reddish brown on standing.

## EFFECT OF TRANSUDATE FROM STRANGULATED INTESTINE ON CAPILLARY PERMEABILITY

While the chief concern about the vascular action of the toxic material in strangulation has been its vasodepressor effect, we believed that it might be worth while to investigate its action on capillary permeability, for if such an effect were present it would account for wide spread plasma loss and contribute to the shock-like condition encountered in intestinal strangulation. Menkin has developed a simple way of determining the effect of substances on capillary permeability and has shown that in an inflamed area a substance "leukotaxine" is found which increases capillary permeability.



ity. This finding has been confirmed by Freed and Lindner among others, and more recently Shleser and Freed have shown that a similar response can be obtained with peptone.

In carrying out the Menkin test freshly obtained transudate was used. An 0.2 cubic centimeter portion of transudate was diluted with an equal quantity of isotonic saline and injected intracutaneously into the shaved abdominal skin of a rabbit. As a control a similar quantity of isotonic saline alone was injected in another portion of the abdominal skin. After 3 to 5 minutes 10 cubic centimeters of a 1/35 per cent solution of trypan blue was injected intravenously. Within a few minutes there was a concentration of dye at the site of the transudate injection, and none where the control solution was injected. In this manner the transudates from 18 dogs obtained within 4 to 6 hours of intestinal strangulation invariably gave a positive Menkin test in 18 rabbits. A similar positive reaction was obtained in 8 rabbits after 8 specimens of transudate were passed through a Seitz filter although a weaker reaction sometimes occurred with the filtered material.

It is thus apparent that a substance capable of increasing capillary permeability is present in the transudate from strangulated intestine and the possibility is thus established that part of the reaction to strangulation results from such toxic material entering the blood stream and increasing capillary permeability. The result of such a widespread increase in capillary permeability would be to decrease plasma volume and thus cause a form of shock.

#### NEUTRALIZING ACTION OF ADRENAL CORTEX EXTRACT ON THE CAPILLARY PERMEABILITY EFFECT OF TRANSUDATE FROM STRANGULATED INTESTINE

The possibility that adrenal cortex extract could neutralize the increase in capillary permeability caused by this transudate was suggested by the action of adrenal cortex extract in neutralizing leukotaxine (Menkin, Freed and Lindner) and peptone (Shleser and Freed). To test out this possibility we carried out a 3d series of intracutaneous injections in the rabbits described. In this series

equal parts of adrenal cortex extract<sup>1</sup> and unfiltered transudate were injected and the effect was compared with that from injection of transudate alone. It was found, on comparing the skin reaction at the site of the adrenal cortex extract transudate injection with that of the transudate injection that adrenal cortex extract completely neutralized the capillary effect shown by the transudate in all 12 separate tests.

This result suggests a possible mode of therapy in intestinal strangulation since evidence has recently been adduced that adrenal cortex extract may decrease capillary permeability in other localities than in the skin (Shleser and Asher). It might explain in part at least the beneficial result following the use of adrenal cortex extract obtained by Wohl and associates in experimental intestinal obstruction and that obtained by Heuer and Andrus with adrenal cortex extract in counteracting the vasodepressor action of injections of aqueous extracts of closed intestinal loops.

#### THE NEUTRALIZATION BY ADRENAL CORTEX EXTRACTS OF THE TOXIC EFFECT ON MICE OF THE TRANSUDATE FROM THE STRANGULATED INTESTINE OF THE DOG

The suggested benefit of adrenal cortex extract in neutralizing the capillary effect of transudate was further explored by observations on mice. Mice were selected as the test animal in these further studies because their small size permitted the use of larger series for comparison. It has been shown by Donaldson and associates that mice are susceptible to the toxic action of the contents of dog's strangulated intestines. In the present studies the transudate of strangulated intestine from 8 dogs operated upon on the same day were pooled and used. Preliminary tests showed that this material like the preceding gave a positive Menkin reaction in rabbit skin. The transudate was diluted with an equal part of isotonic saline and injected intraperitoneally in a group of mice each mouse receiving 0.4 cubic centimeter of the transudate-saline solution. At the same time another group of mice each received intraperitoneally 0.4 cubic cen-

<sup>1</sup>Adrenocortical extracts of the adrenal cortex extract used in these studies were supplied by Dr. D. Kline of the Ohio Laboratories.

TABLE I—EFFECT OF ADRENAL CORTEX EXTRACT UPON MORTALITY OF MICE INJECTED INTRAPERITONEALLY WITH TRANSUDATE OF DOGS' STRANGULATED INTESTINE

Material injected	No of mice in series	No of mice dead in 24 hours	Mortality %
Transudate in saline—0.2 c.c. transudate in 0.2 c.c. isotonic saline per mouse	40	34	86
Transudate plus adrenal cortex extract—0.2 c.c. of each per mouse	43	21	48

TABLE II—EFFECT OF VARYING TIME OF INJECTION AND TOTAL AMOUNT OF ADRENAL CORTEX EXTRACT UPON MORTALITY OF MICE INJECTED INTRAPERITONEALLY WITH TRANSUDATE OF DOGS' STRANGULATED INTESTINE

Material injected	No of mice in series	No of mice dead in 24 hours	Mortality %
Transudate in saline—Control group—0.2 c.c. transudate in 0.2 c.c. isotonic saline per mouse	87	61	70
Transudate plus adrenal cortex extract—Group I—0.2 c.c. of each per mouse	54	23	42
Transudate plus adrenal cortex extract—Group II—0.2 c.c. of each per mouse preceded 1 hour earlier by 0.2 c.c. of cortex extract	38	12	34
Transudate plus adrenal cortex extract—Group III—0.2 c.c. of each per mouse preceded 1 hour earlier and followed in an hour by injections of 0.2 c.c. of cortex extract	21	7	33
Transudate plus adrenal cortex extract—Groups I, II and III	113	42	37

timeter of a mixture of equal parts of transudate and adrenal cortex extract. The measure of the effect was the death rate of the mice within 24 hours. It will be seen from Table I that 86 per cent of the control mice receiving transudate were dead in 24 hours, while in those receiving adrenal cortex extract in addition the mortality rate was 48 per cent, a reduction in mortality of about  $\frac{1}{2}$ . It was also noted that the animals which survived after receiving adrenal cortex extract were much livelier than the surviving animals which received only transudate.

The results in the first series were confirmed in a second series of mice in which the pooled transudate from 7 dogs was used. In this

TABLE III—EFFECT OF VARYING RATIO OF ADRENAL CORTEX EXTRACT TO TRANSUDATE OF DOGS' STRANGULATED INTESTINE INJECTED INTRAPERITONEALLY UPON MORTALITY OF MICE

Material injected		Ratio adrenal cortex extract to transudate	No of mice in group	No of mice alive at end of		
Transudate c.c.	Adrenal cortex extract c.c.			3 hrs	7 hrs	14 hrs
0.5	0.0	Control	4	0	0	0
0.5	0.1	1:5	4	0	0	0
0.5	0.25	1:2	4	1	0	0
0.5	0.5	1:1	8	4	0	0
0.5	1.0	2:1	4	4	0	0
0.1	0.5	5:1	4	4	4	2
0.25	0.5	2:1	4	4	0	0
1.0	0.5	1:2	4	0	0	0

TABLE IV—EFFECT OF SEITZ-FILTRATION OF TRANSUDATE OF DOGS' STRANGULATED INTESTINE UPON MORTALITY OF MICE WHEN INJECTED INTRAPERITONEALLY

Material injected	No of mice in series	No of mice dead in 24 hours	Mortality %
Unfiltered transudate in saline—0.2 c.c. transudate in 0.2 c.c. isotonic saline per mouse	40	34	86
Seitz filtered transudate in saline—0.2 c.c. filtered transudate in 0.2 c.c. isotonic saline per mouse	19	1	1
Seitz filtered transudate plus adrenal cortex extracts—0.2 c.c. of each per mouse	20	1	1

series, the mice were divided into 4 groups: the first 2 groups were handled as in the preceding series, the 3d group received an additional adrenal cortex extract injection (0.2 c.c. per mouse) 1 hour before the transudate-adrenal cortex mixture was injected, and the 4th group received not only this preliminary adrenal cortex extract injection but also a subsequent one (0.2 c.c. per mouse) 1 hour after injection of the transudate-extract mixture. It will be seen from Table II that 70 per cent of the control mice receiving transudate were dead in 24 hours, while only 37 per cent of those receiving adrenal cortex extract in addition succumbed in this period, the mortality in this series, as in the last, was reduced

about  $\frac{1}{4}$  by adrenal cortex extract. In this series also as in the first the surviving animals receiving cortex extract were livelier than those receiving transudate alone. No significant change in mortality was observed to follow the administration of adrenal cortex extract before or both before and subsequent to the injection made at the time the transudate was administered although the trend was to reduce the mortality from 43 per cent (group I of Table II) to 34 and 33 per cent respectively (groups II and III).

A much clearer quantitative relationship between the amounts of transudate and adrenal cortex extract was shown in another series of mice in which the ratio was varied. In them the pooled transudate from 8 dogs was used. In this series, the mice were divided into 8 groups of 4 each (and 1 of 8) and the proportion of transudate and adrenal cortex extract injected simultaneously was varied. The measure of effect in these mice was their survival at the end of 3, 7 and 14 hours. The results are summarized in Table III and it is clear from this table that survival was lengthened when the proportion of adrenal cortex extract to transudate increased the results being surprisingly consistent.

It would appear from these experiments that adrenal cortex extract definitely neutralizes, at least in part, the toxic action of transudate of strangulated intestine.

As early as 1911 Murphy and Vincent found that the toxic material of strangulated intestine obtained from the lumen of the cat lost its toxicity when passed through a Berkefeld filter. As has been pointed out we found that Seitz filtration of the transudate lessened but did not abolish the Menkin reaction in rabbit skin. We tested the toxic effect of the transudate in our first series of mice in a similar way by passing the material through a Seitz filter. As shown in Table IV the filtered transudate was much less toxic to mice than was the unfiltered material. Thus only 1 mouse in 19 succumbing in 24 hours a mortality of 5 per cent and this low mortality was also present when adrenal cortex extract was added. However the animals receiving adrenal cortex extract were more lively and active than those receiving filtered transudate

alone. In fact the latter animals were all lethargic and appeared ill. Thus adrenal cortex extract appears to prevent even the milder toxic effects of Seitz filtered transudate from strangulated intestine.

The lessening of toxicity by Seitz filtration does not necessarily indicate that most of the toxicity is due to bacteria contained in the transudate. It must be recalled that Seitz filters remove not only bacteria when present but, being positively charged electrically they prevent the passage of positive charged inanimate material in suspension (Kramer). It is therefore quite possible that the toxic material in the transudate consists in large part of such a positively charged suspension or that the toxic material is adsorbed in large part upon such a suspension.

#### SUMMARY AND CONCLUSIONS

Experiments utilizing the peritoneal transudate of the dog a strangulated intestine have shown that

1. The transudate increases capillary permeability as demonstrated by the Menkin reaction in rabbit skin. This effect is somewhat decreased when the transudate is passed through a Seitz filter. This effect of unfiltered and filtered transudate on capillary permeability is neutralized by adrenal cortex extract.

2. The transudate is toxic to mice when injected intraperitoneally making them ill, lethargic and leading to a high mortality within 24 hours. These ill-effects are markedly reduced by passing the transudate through a Seitz filter particularly as far as 24 hour mortality is concerned. A less striking but nevertheless definite reduction of mortality is effected by adding an equal amount of adrenal cortex extract to the unfiltered transudate before injection the mortality being reduced to about  $\frac{1}{4}$ . In addition adrenal cortex extract lessens the lethargy of the mice surviving 24 hours, and this is also found to be true in mice receiving Seitz filtered transudate. There is suggestive evidence that the neutralizing effect of adrenal cortex extract upon the reaction of mice to transudate is proportional to the relative amounts of each employed in creating the relative proportion of adrenal

cortex extract produces a definite effect on the survival time of the mice

It is concluded from these experiments that toxic material which can pass into the blood stream is produced by strangulation of the intestine. Such absorbed toxic material may account in large part for the effects observed in strangulation. These experiments further suggest that the toxic material acts in part to increase capillary permeability leading to escape of plasma, so producing shock. Adrenal cortex extract neutralizes the action of the toxic material in the transudate by preventing the increase in capillary permeability and possibly in other ways not revealed by our experiments. On the basis of our experiments the use of adrenal cortex extract in clinical intestinal strangulation appears worthy of trial.

## REFERENCES

- 1 COOPER, H S Arch Surg, 1928, 17 915
- 2 DONALDSON, J K, SIVEL, I B, and LEWIS, N Arch Surg, 1941, 43 511
- 3 FOSTER, W C, and HAUSLER, R W Arch Int Med, 1924, 34 697
- 4 FREED, S C, and INDENFR, I Am J Physiol, 1941, 134 258
- 5 HARKINS, H N Surgery, 1941, 9 231, 447, and 607
- 6 HERRIN, R C, and MEYER, W J Arch Int Med, 1933, 51 152
- 7 HILF, G J, and ANDRUS, W DEW Ann Surg, 1938, 100 734
- 8 KRAMER, S P Chapter XLI in Newer Knowledge of Bacteriology and Immunology, edited by Jordan, L O and Falk, I S Chicago University of Chicago Press, 1928
- 9 MINKIN, V Am J Physiol, 129, 691 1940
- 10 MURPHY, I T, and VINCENT, B Boston M & S J, 18, 684 1911
- 11 SHLESER, I H, and ASHLER, R Am J Physiol, 138, 1 1943
- 12 SHLESER, I H, and FRIED, S C Am J Physiol, 137, 426 1942
- 13 WOHL, M G, BURNS, J C, and PFEIFFER, G Proc Soc Exp Biol, N Y, 1937 36 549

# THE DERMATOME PATTERN GRAFT AND ITS USE IN RECONSTRUCTION OF THE HANDS

FRANK F. KANTHAH, M.D. Major M.C., A.U.S., Atlanta, Georgia

**M**ANY extensive and severe burns to the hands involving both the dorsal and palmar surfaces are being seen in the present conflict.

For the reconstruction of injuries to the cutaneous covering of the hands, the free transplant of the skin holds many advantages over the prolonged pedicle flap operations. The various indications for the use of each type of free skin graft and the pedicle flap in hand reconstructions have been recently described by Koch. The many advantages of thick split grafts as developed by Blair and Brown (1, 2) and others in the repair of these injuries are apparent. The introduction of the dermatome into plastic surgery by Padgett has resulted in a method of obtaining uniformly large grafts of a predetermined thickness with sharp straight edges, more suitable for smaller reconstructions than the razor graft. By means of the dermatome in the manner to be described, grafts of a specific pattern may be obtained for the reconstruction of extensive injuries of the hands and other regions.

## TECHNIQUE

The following procedure has been utilized for the past 2 years in cutting pattern grafts of split thickness skin for the reconstruction of certain areas. In my experience the suggestion of utilizing the dermatome to cut certain complicated patterns of skin by painting out the undesired portion with talcum powder has not proved feasible, because the dermatome will not uniformly pick up and follow such a devious route. Reconstructions of the dorsum of the hand present complicated patterns due to prolongation of cicatrix along the fingers. In this situation, the dermatome pattern graft, as outlined here, has proved to serve a definite place. Under tourniquet the scar of the hand is carefully separated in its entirety from the remaining subcutaneous base (Fig. 2)

In exerting traction on the scar during excision, it is necessary to be careful not to cut into vessels and nerves which are pulled up with the portion of tissue being excised. By this painstaking dissection the entire cicatrix including its extensions along the fingers is removed. Bleeding vessels are caught as they are cut and tied with finest silk. A large piece of hard faced sterile filter paper is pressed over the denuded area and the outline of the surface to be grafted is imprinted on the paper which is then removed and trimmed with scissors until an accurate pattern of the defect is obtained. The skin and subcutaneous surfaces of the pattern are distinctively marked with indelible pencil so that each surface may be readily identified. If this precaution is not carefully observed, the pattern graft will be cut backward so that the right side will be fitted into the left side of the defect. Wet gauze sponges are placed on the hand and it is then firmly dressed with a sterile roller gauze bandage following which the tourniquet is released. The donor site for the skin graft which has previously been prepared is cleaned with ether and an estimate of the area of skin to be removed is made. The dermatome and donor site are coated with cement and the dermatome drum is then pressed to the donor site and a split skin graft of the desired thickness is secured. On the dorsum of the hand a graft of 0.018 inch is sufficient in thickness for satisfactory coverage and protection. The entire sheet of skin is cut with the dermatome to the desired length and separated from the donor site. The drum is then placed in its stand and the pattern previously prepared is placed on the skin still adherent to the drum taking care that the skin surface of the pattern is in contact with the raw surface of the graft as marked when the pattern is made. It will be found that the pattern will stick firmly to the skin graft, due to the capillary action of the filter paper (Fig. 3). With a scalpel the skin is now



Fig 1



Fig 2



Fig 3



Fig 4

Fig 1 Cadet C H Heavy, hypertrophic scarring of the dorsum of hands following 2d and 3d degree burns Scars were throbbing, tender to palpation, and sensitive to weather changes Minor injuries to the hands caused the scars to break down

Fig 2 Entire scar of left hand excised, including prolongations of scar up the fingers The normal subcutaneous bed present under the scar is shown

Fig 3 The pattern of the area to be grafted, cut of hard faced sterile filter paper, is placed on the dermatome skin graft, 0.018 inch thick, with the skin side of the pattern in contact with the raw surface of the graft. If the pattern is turned over to place subcutaneous side against raw surface of the graft, the skin graft will be cut in reverse

Fig 4 The skin graft is cut along the outline of the pattern against the dermatome drum with a scalpel The pattern adheres to the skin graft making it unnecessary to hold it in position against the graft

cut around the pattern against the drum (Fig 4) Excess areas of skin are removed from the drum until only the pattern graft remains Small hemostats are placed on the edges of the graft, and it is peeled slowly away from the drum, during which time it is lightly dusted with sulfanilamide powder which neutralizes

the stickiness of the cement remaining on the graft Ordinarily, no sulfanilamide powder is used under the graft, although we have seen no untoward effects on healing from its use The bandage is now carefully removed from the hand and further small bleeding points are caught and tied with fine silk The graft is

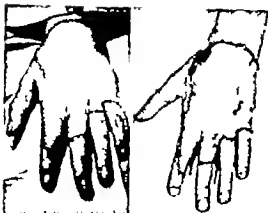


Fig. 5.

Fig. 6.

Fig. 5. The pattern graft sutured in position with interrupted and continuous sutures of fine, black silk. The graft has been perforated and is ready for dressing. The exact fit of the skin graft to the defect is well shown.

Fig. 6. Graft 12 days after first dressing. A complete take of skin has ensued. A small superficial blister may be seen.

transferred to the hand and sutured in various strategic points with interrupted fine silk sutures, following which a continuous suture may be used for the final approximation (Fig. 5). The graft is perforated and covered with a single layer of xeroform gauze followed by several wet gauze sponges smoothly laid over the graft and on top of which are placed marine sponges sufficiently large to cover the entire grafted area. The moist gauze sponges soak up any oozing which occurs during the early period of fixation of the graft. A light plaster cast is applied over the entire hand and forearm to immobilize the hand and fingers effectively. This dressing is permitted to remain 10 days unless signs of infection beneath the graft are evident. At the end of this period of time the sutures may be removed and the graft lightly dressed with a grease gauze preparation such as xeroform (Fig. 6). Motion of the fingers and hand should be restricted for another 10 days.

Cadet C. H. (Figs. 7-8) aged 18 years, received severe 3d and 4th degree burns of the hands, face, and legs airplane crash. The hands and face were treated with sulfathiazole ointment, and the burned areas of the legs debrided and tanned with tannic acid and silver nitrate. The patient was transferred to La. Son General Hospital for further care. The legs were treated by the application of split skin

grafts following removal of the eschar and healed without event. The burns of the hand healed with the formation of a large hypertrophic scar along the dorsum. This scar was throbbing, tender to palpation and sensitive to rather change. The cicatrix was excised from the right hand and pattern dermatome graft 8 inch in thickness sutured in position. Healing uneventful and satisfactory restoration of cutaneous covering was achieved.

Early grafting of the hands following a deep burn of this type would have minimized the length of the convalescent period and probably removed the necessity for future grafting. We seldom see patients in this early state however.

McC. A. S. aged 4 years, received 2d and 3d degree burns of the face, neck, chest, and hands when he was sprayed with burning gasoline while on duty. The burned areas were treated with tannic acid and a number of pinch grafts were subsequently applied to the granulating areas of the chest and shoulder. The patient was eventually transferred to La. Son General Hospital for further care. On his admission here the burned areas of the hands were completely healed several small grafting scars were present on the chest and shoulder intervening areas between the small deep grafts which had been previously applied. The entire dorsum of the right hand had healed with heavy keloidal scar which extended up the arm, through the distal one-third, and was continuous along the fingers (Fig. 7). The left hand presented heavy scar along the left thumb and wrist on both the dorsal and volar surface. The scars were so heavy as to interfere with effective hand and finger movements. Areas over the knuckles could crack and bleed following activity of the hands. The scar of the left hand was excised and replaced with pattern graft 8 inch in thickness as described. Complete healing ensued. The right hand was reconstructed approximately 30 square inches of skin as used to replace the scars of the rest of the hand and the fingers. A satisfactory result as obtained (Figs. 8-9). There is good motion of the hand and scar formation about the borders of the graft is minimal.

We have utilized this technique for the covering of aseptic denuded areas in cases in which previously a full thickness skin graft would be utilized, or in which a large split skin graft would be sutured into the defect by overlapping the margins or trimming the periphery during suturing. The use of the pattern graft results in a finer ultimate scar juncture with the surrounding normal skin and is actually time saving in suturing the graft in position for extensive reconstructions as both hands,

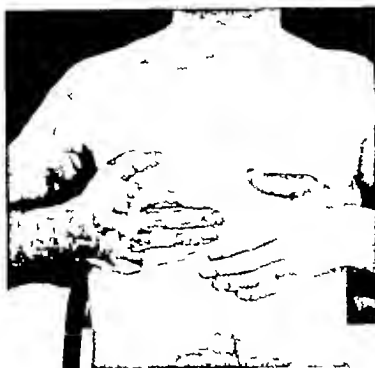


Fig 7

Fig 7 Pvt A S Extensive burn scar of dorsum of right hand and wrist. The keloidal area of the left thumb and hand has been repaired with a pattern dermatome graft

Fig 8 Pvt A S Repair of the left and right hands with two pattern grafts restoring approximately 50 square inches



Fig 8



Fig 9

of skin to the right hand and forearm Photographed 7 months after repair Function and texture of grafted skin is excellent It is more deeply pigmented than the adjoining skin

Fig 9 Pvt A S

complete full thickness use is often prohibitive because of the large area of skin to be utilized, and on the dorsum of the hand is quite unnecessary as sufficient cutaneous protection may be obtained with the split graft

On large palmar contractures, in which sufficient subcutaneous tissue remains, the scar is excised and replaced with a pattern, thick split skin graft Subsequent contractures are corrected with small full thickness grafts Smaller areas of cicatrix on the palmar surface are treated by the usual full thickness skin grafting technique However, in extensive

cicatrices, the large area to be covered by full thickness grafts makes the method almost prohibitive, particularly if other areas of the body remain to be reconstructed We have, therefore, reserved the full thickness graft for the final stages of correction, relying principally on the pattern dermatome graft for the major reconstruction This procedure has resulted in the provision of a good protective covering to the palm and a good ultimate functional result

Sgt J F R, aged 28 years, received severe 3d degree burns of the palmar surfaces of both hands,

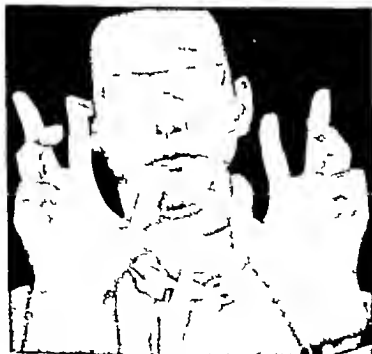


Fig 10

Fig 10 Sgt J R Burn contractures of the palms of right and left hands With the exception of the 1st and 2d fingers of each hand, the digits are fixed by heavy scar

Fig 11 Sgt J R The major correction has been accomplished with pattern dermatome grafts, 0.024 inch in thickness Contractures along the suture line of each



Fig 11



Fig 12

thumb remain to be corrected with small full thickness grafts This patient forms keloids

Fig 12 Sgt J R Illustrating satisfactory function of hands at the present time following restoration of the palmar surfaces with the application of pattern dermatome grafts



and 2d degree burns of the forearms, while on d t. Before admission to Lawson General Hospital, he was treated by debridement of the burned areas and tannic acid and allowed to heal spontaneously following removal of the eschar. A very heavy hypertrophic scarring of both palmar surfaces extending along the flexor surfaces of certain fingers developed. Typical rigid claw hands without function developed and the patient was transferred to Lawson General Hospital for reconstruction, with all burned areas completely healed (Fig 1). In several stages, the entire cicatrices of the right and left hands were excised in their entirety and the palmar surfaces were restored with pattern dermatome grafts 0.024 inch in thickness. Satisfactory healing and extension of the fingers followed these procedures. Subsequent contractures of the fingers and thumb were released by further excision of the scar junction between graft and normal palmar skin and implantation of small full thickness skin grafts (Figs. 2-5).

a) At present fairly satisfactory function of the hands is present, although a few additional minor adjustments remain to be done. In this case, the use of thick dermatome pattern grafts simplified the placing of a complicated graft to the hand and at the same time provided excellent covering of the palmar fat which was approximately normal in extent. Whenever an area of skin is removed from this patient, keloids form thereby complicating his treatment.

Keloid formation is not a contraindication to skin grafting. On the contrary we have noted, as have others, that there is no tendency for keloidal formation in the grafted area except at the suture line. This may be minimized by meticulous coaptation of the edges between skin and skin graft and perhaps early x ray therapy to the suture line, although the efficacy of this medium has not always been impressive. The donor sites frequently exhibit keloid formation even from the thinner split grafts, and in areas where full thickness grafts of skin have been removed heavy keloidal scars usually develop. It is therefore desirable to remove skin for grafting from areas in which the functional or cosmetic after effects are of no significance.

It is realized that if insufficient palmar fat remains so that palmar fascia or tendons are exposed after excision of the cicatrix, it is necessary to provide a fatty pad in addition to the skin covering for the achievement of a satisfactory result. This may be accomplished

by the use of a pedicle flap from the abdomen or other accessible site. Because of the detailed steps in reconstruction occasioned by the use of a pedicle flap this is not the method of choice in the repair of hand injuries. It remains one of necessity. In addition the pedicle flap provides a thick bulky reconstruction which does not simulate the normal covering of the hand as closely as does the free transplant placed on the natural subcutaneous fat bed. This additional thickness may be reduced by subcutaneous thinning procedures, but adds to the length of hospitalization and convalescence.

#### SUMMARY

A method of utilizing the dermatome to provide a pattern graft has been developed, and the uses of the dermatome pattern graft in the repair of cutaneous injuries of the hands is described. This procedure consists in the removal of a split graft with the dermatome, cutting a pattern of the area to be grafted and transferring the pattern to the dermatome drum where the outline is cut on the drum. The graft is subsequently transferred to the recipient area where it is sutured and dressed in the customary manner. The method thus described represents a combination of full thickness and split thickness grafting technique, and is especially suitable for the grafting of large areas of irregular outline. Since the donor site requires no additional surgery for closure as does the full thickness grafting technique this procedure simplifies the problem of restoring areas of considerable size and complicated design. The advantage of treating keloidal areas by complete excision and skin grafting by this method is mentioned. Several cases illustrating the use of this method in the repair of cutaneous injuries to the hands are presented.

#### REFERENCES

1. BLAIR, V. P. and BROWN, J. B. Surg. Gyn. Obst. 92, 49 82-97
2. BROWN, J. B. Ann. Surg. 43, 47 952-970
3. KOCK, S. L. Surg. Gyn. Obst., 64 7 57-77
4. PARDETT, EARL C. Surg. Gyn. Obst. 92, 60 779-793

## ESOPHAGOBRONCHIAL FISTULA

LOUIS H. CLERF, M.D., F.A.C.S., E. E. COOLEY, Colonel, M.C., A.U.S., and J. J. O'KEEFE, M.D.,  
Philadelphia, Pennsylvania

FISTULAS between the food passages and the tracheobronchial tree have been classified into four main groups. A study by Monserrat of reported cases in the world literature revealed 222 congenital, 367 neoplastic, 41 infectious, and 40 traumatic fistulas. These figures probably represent but a small proportion of the total number, particularly of the congenital and neoplastic groups since these commonly terminate fatally and many never are recorded in the literature. Infectious and traumatic forms, although few in number, offer a better prognosis and from this standpoint alone are of greater interest medically.

Cases due to trauma are commonly caused by swallowed irregular or pointed foreign bodies, such as bones. The trachea or left main bronchus should be more commonly involved because of their close proximity to the esophagus. The case reported by Murtagh and Tyson affords a classical example. Although there was a history of swallowing a foreign body, roentgen-ray studies of the swallowing function were negative. The subsequent development of cough when swallowing fluids and the demonstration by roentgen-ray examination of swallowed barium entering the left main bronchus established the diagnosis of esophagobronchial fistula. At esophagoscopy no foreign body was found although an area of ulceration and inflammation was observed. Gastrostomy was performed, and at a subsequent esophagoscopy a bone was found and removed. The fistula healed promptly and the patient made a satisfactory recovery. It is not always possible to elicit a foreign body history or find a foreign body esophagoscopically so that a sharp distinction between traumatic and infectious cases cannot always be made.

Infectious cases may be of syphilitic, tuberculous, or nonspecific origin. A case of tracheoesophageal fistula of syphilitic origin ob-

served at the clinic was reported by Bucher and Ono. Monserrat reported 3 cases of tuberculous origin. This more often occurs in children and apparently is the result of the breaking down of a tuberculous lymph node. The origin of fistula in adults is not entirely clear. In a case previously reported (2) there was a communication between the esophagus and left lower lobe bronchus apparently of 7 years' duration. There was no history of foreign body, syphilis, or tuberculosis, in fact the only abnormal findings noted were cough when taking liquids and the presence of a chronic pulmonary suppuration involving the lower lobe of the left lung. In this case the esophageal end of the fistula was cauterized with silver nitrate and apparently closed for a time only to recur later. External surgical treatment was carried out, but the patient died from a bronchopulmonary complication.

Two additional cases of esophagobronchial fistula have been observed at the bronchoscopic clinic, Jefferson Hospital. These are of interest because of the cause, duration, clinical course, and measures employed in obliterating the esophageal end of the fistula.

**CASE 1.** Mrs. R., aged 61 years, was admitted to the clinic during January, 1941, with a diagnosis of bronchoesophageal fistula which had been made elsewhere during April, 1940.

The family and personal medical history was negative. During January, 1940, she was admitted to the Letterman General Hospital for study. There was a history of nonproductive cough, mild digestive disturbances, and slight fever of about 2 weeks' duration. The cough later became productive and there was some hemoptysis. A diagnosis of pulmonary abscess involving the middle lobe of the right lung was made and this was treated by medical measures including bronchoscopic drainage. While convalescing from the pulmonary infection it was noted during April, 1940, that there often were paroxysms of coughing associated with drinking fluids, particularly water. This difficulty became progressively worse, and at one time the patient had a severe strangling attack after swallowing solid food. A fluoroscopic study of the swallowing



Fig. Roentgenogram made after patient swallowed small quantity of indium oil revealed shadow extending from the wall of the esophagus into the right lung field. Subsequent studies with barium in larger quantity revealed large quantity of barium in the right bronchus.

unction after the administration of barium demonstrated the opaque material entering the right bronchus. A diagnosis of esophagobronchial fistula as made and gastrostomy as performed. Cough continued to be troublesome and there as some vomiting at times foul. During the latter part of July 1910, mass of dark necrotic material, which inhibited the appearances of necrotic lymph nodes as coughed up. Following this there as definite improvement in the bronchopulmonary symptoms. He still as unable to take foods, fluids without inducing severe cough. Bowel secretions also are frequently coughed up, and occasionally these are blood tinged. On admission to clinic in January 1911 patient general condition appeared satisfactory. A gastrostomy tube as used as unable to take foods, fluids without coughing. She had to lie on left side with shoulders elevated when recumbent to avoid provocation of cough.

At esophagoscope, there found small elliptical depression on the lesser and right lateral wall of the esophagus, 30 centimeters from the upper end. The surrounding mucosa appeared normal. Upon insertion the small flexible tube revealed that it could be passed about centimeter beyond the termination of the small depression. Bronchoscopy revealed moderate inflammation of the mucosa of the right main bronchus extending to the middle lobe bronchial orifice. Esophagoscope as performed with fluoroscopic assistance and iodized oil in

stilled into the depression on the right lateral wall of the esophagus. A few drops of oil were seen to pass into the right of the esophagus in the neighborhood of the right main bronchus, but it was not possible to localize this accurately with relation to the bronchial tree because of the small quantity used. This barium mixture then as swallowed and considerable quantity as seen to emerge from the right side of the esophagus several centimeters below the carina (Fig. 1). Immediately upon making this observation the patient had a severe paroxysm of coughing and it was apparent that considerable quantity of barium had entered right bronchus as a thin coating could be observed along its walls.

In view of previous unsatisfactory experiences with silver nitrate sclerosing agent it as decided to employ 5 per cent acid acriflavine solution to obliterate the fistula, and as he saturated with this are applied for total of 6 minutes. Three additional applications are made at intervals of 2 weeks. While there was definite subjective improvement observed, since the patient could now lie on the right side without provoking cough, the fistula still remained patent. Following this silver nitrate 1:5 per cent and later 50 per cent solution applied on occasions but with no apparent obliteration of the fistula. It as then concluded that sodium hyposulfite could probably give better re-



Fig. Roentgenogram made after patient swallowed quantity of barium revealed considerable the right bronchus and also showed definite communication between the right wall of the esophagus and the right bronchus. This promptly induced coughing and more general distribution of the barium which however disappeared from the bronchial tree within 24 hours.

## CLERF, COOLEY, O'KEEFE ESOPHAGOBRONCHIAL FISTULA

sults in view of its excellent sclerosing effects in the esophagus when swallowed accidentally. Crystals of sodium hydroxide were fused on a metal applicator slightly at its distal end, and this was introduced into the esophageal end of the fistula and retained in place for 3 minutes. Another application was made in 3 weeks. Four weeks later the patient was examined esophagoscopically and by roentgen-ray study. There was noted considerable scarring of the esophageal wall at the site of the fistula but nothing could be found to suggest any communication or opening. A roentgen-ray study of the esophagus with a thin barium mixture revealed no evidence of communication between the esophagus and bronchus. The patient was allowed to take foods by mouth and had no difficulty. There were no respiratory symptoms. The gastrostomy tube was removed about 4 weeks later and the fistula closed.

The patient has been free from all symptoms for over 18 months.

**CASE 2** Mr L., aged 60 years, was admitted to the clinic during May, 1941. His complaints were inability to take any liquid foods by mouth or to sleep on his right side for a period of 32 months. The family and personal medical history was negative. During July, 1938, he developed what was considered a mild attack of grippe. During the latter part of the illness, which lasted about 2 weeks, it was noticed that paroxysms of coughing occurred when taking liquid food, particularly water. This became very troublesome and his physician instituted feeding by tube. Because of the persistence of coughing when food was taken a roentgen-ray study of the swallowing function was made. This revealed a large esophagobronchial fistula, the communication being between the esophagus and the right main bronchus. Gastrostomy was recommended, but the patient preferred to continue with feeding by tube since he had no difficulty with passing it and had become accustomed to taking liquid feedings and water several times daily. Solid foods caused little distress but liquids could not be swallowed without provoking severe paroxysms of cough.

When admitted to the clinic during May, 1941, he had taken liquid foods and water by tube for 32 months. He could not lie on right side and often was awakened on changing posture. He had slight cough apparently due to swallowing mouth secretions which passed from esophagus into right bronchus.

Roentgen examination of the swallowing function on May 17, 1941, revealed a large esophagobronchial fistula the diameter of which was approximately 5 millimeters (Fig 2). When using thin barium mixture a considerable quantity was observed to flow into the right bronchus. At esophagoscopy there was a small depression on right lateral wall of the esophagus 31 centimeters from upper teeth. A small flexible tipped aspirating tube was passed without difficulty into fistula a distance of 3 centimeters.

Bronchoscopic examination revealed marked inflammation and edema of the mucosa of the right bronchus extending down to the orifice of the middle

lobe orifice. A small opening approximately 2 millimeters in diameter was observed along the inner wall of the bronchus, and frothy secretion was seen coming from this. A flexible tipped tube could be passed into the bronchial end of the fistula for a distance of about 2 centimeters.

Having observed the beneficial effects of sodium hydroxide as a cauterizing agent in the previous case we proceeded with this method of treatment. A bead of sodium hydroxide crystals fused on the tip of a small flexible aspirating tube was carried into the esophageal end of the fistula and allowed to remain for 3 minutes. When observed 3 weeks later the patient stated that he had relatively little cough and had gained 8 pounds in weight. At esophagoscopy the small pouch previously observed was the seat of marked inflammatory changes, but no definite communication could be noted. Additional sodium hydroxide crystals were applied and allowed to remain for 2 minutes. The patient was observed 5 weeks later. He was then able to take liquids by mouth without distress and could lie on his right side without exciting paroxysms of coughing. There were no respiratory symptoms. Esophagoscopy examination revealed a small pouch on the right lateral wall of the esophagus, but there was no ulceration nor could any communication be demonstrated. A roentgen ray study of the swallowing function revealed no evidence of barium entering the bronchus, the esophageal outline itself appeared normal. Patient has no disturbances in swallowing, subsists on normal diet and has exhibited no symptoms since last esophagoscopy treatment 1½ years ago.

## SUMMARY

Two patients with esophagobronchial fistula between the right main bronchus and esophagus which existed for 9 and 32 months, respectively, are reported. No definite cause could be demonstrated although one patient had developed a pulmonary abscess and coughed up a mass of necrotic tissue immediately preceding the development of symptoms. There was no apparent tendency for the fistula to close after the esophagus was placed at rest. Prompt closure of the esophageal end of the fistula resulted following the esophagoscopy application of sodium hydroxide crystal fused on a curved metal applicator and carried into the fistula for a distance of several centimeters. Both patients have been free from symptoms over 18 months.

## REFERENCES

1. BUCHER, C. J., and ONO, J. *Am J Path*, 1934, 10 391
2. CLERF, L. H. *Ann Otol Rhinol*, 1933, 42 920
3. MONSERRAT, J. L. *Rev As méd argent.*, 1941, 55 438
4. MURTAGH, J. A., and TAYSON, M. D. *N England J M*, 1940 222 494

# FACE AND PERSISTENT BROW PRESENTATIONS

A. CHARLES POSNER, M.D. F.A.C.S., and IRWIN M. BUCH, B.S., M.D.  
New York, New York

IN this paper an analysis is given of 87 face and 13 persistent brow presentations which occurred at Harlem Hospital, New York, between January 1 1914 and June 30 1947. The results obtained and the conclusions drawn from them are compared with accepted views regarding this problem. For the years 1914 through 1929 departmental summaries rather than official bedside records were used. As the departmental summaries were not complete in all respects the cases of these earlier years are analyzed only if reliable data are available.

## INCIDENCE

Among the 46,038 deliveries at Harlem Hospital during the interval mentioned there were 87 face and 13 persistent brow presentations. Thus there was 1 face presentation in 529 deliveries or 0.19 per cent, 1 persistent brow presentation in 3,543 deliveries, or 0.03 per cent, and a combined ratio of 1 in 46 deliveries or 0.22 per cent. The ratio of face to persistent brow presentations was 6.7 to 1 which compares to most series.

However the absolute incidence of 1 face presentation in 529 deliveries compares favorably only with the ratios of Tweedy and Schumann of 1 in 587 and 1 in 400 respectively and is in contrast with the accepted figure of 1 in 200 which is probably taken from Pinard's series of 90,000 cases in 1889 and from Markoe's series of 60,000 cases in 1909.

Our incidence of 1 persistent brow presentation in 3,543 deliveries is not far removed from the 1 in 3,000 found by DeLee (1) but differs greatly from the usually cited figure of 1 in 1,500 to 2,000 cases (18).

## ETIOLOGY

In this series, the records of 79 cases were complete for a consideration of etiology. In

46 cases, or 58.2 per cent, 1 or 2 of the 16 known predisposing factors—exclusive of multiparity—were present, 2 being found in 5 of these cases and a single factor in 41. None of these causes were operative in the remaining 33 cases, or 41.8 per cent.

The number of cases in which these factors were found either alone or in combination, was

	Cases
Contracted pelvis	3
Large child	14
8 5 to 10 pounds	
10 pounds and over	3
Coils of cord around the neck	2
Fetal monstrosity	5
Asomphaly	
Dactylosomphaly	3
Stemogocle	
Hydranekia	4
Abnormal implantation	4
Placenta previa	
Low implantation	
External version	
Combinations of the above factors	3
Hydranekia and large child	
Hydranekia and contracted pelvis	
Cord around neck and large child	
Placenta previa and large child	

Disproportion was thus present in almost 3 of every 3 cases, or 63.5 per cent in which some etiologic factor was recorded.

Other predisposing factors often mentioned but not found in this series, are cystic tumors of the neck (hygroma) and thyroid tumors, intervention of the arms between the chin and sternum, spastic contraction or congenital shortening of the neck muscles, marked enlargement of the neck or thorax, constriction of the cervix around the neck of the fetus, and fibroids. With the exception of coils of cord around the neck all of these and the afore-

The other serious complication the authors have found to follow this maneuver is premature separation of the placenta. If, however external version is done the following rule should be followed: If the fetal back is to the mother's left, rotation should be clockwise; if the fetal back is to the mother's right, rotation should be counter-clockwise. This allows the cervix to follow the neck and thus favors descent of the head. If the cervix were the leading pole, meeting the soft tissue resistance externally, would be favored.

# POSNER, BUCH FACE AND PERSISTENT BROW PRESENTATIONS

tioned predisposing causes may be diagnosed roentgenographically. All of these conditions either interfere with extension, or obstruct descent after the onset of labor, changing an original occiput or brow to a face (secondary face presentation), primary face presentation is supposedly rare. However, since the completion of this series, we observed a case in which roentgenography proved an unengaged face presentation when the patient was not in labor. Sixteen hours before the onset of labor taken a few hours before the onset of labor showed an engaged vertex presentation. One patient in this series, a quintipara, had three face presentations.

The predisposing factor of multiparity is shown in the following classification, which groups 86 cases according to parity: 24 nulliparas, 18 primiparas, 28 with second to fourth child, 15 with five or more children, and 1 unclassified.

Half of these patients, 43, had had at least two previous term deliveries of living children; sixty-two, or 72.1 per cent, were multiparas, as contrasted with 58 per cent multiparas in all deliveries on our service. This deviation of 14.1 per cent is statistically significant.

Twelve of the entire 100 patients, or 12 per cent, gave birth to premature children. Only 10.3 per cent of the face presentations, but 23 per cent of the persistent brows were premature, as compared with 10 per cent prematures among the entire service.

The average birth weight of 64 full term children was 7 pounds, 12.2 ounces. This contrasts with 7 pounds, 2 ounces, the average birth weight of full term children at Harlem hospital. Eleven of the 64 children weighed over 8½ pounds, of these, 3 weighed 10 pounds or more.

## MECHANISM

It should be noted that the criterion for engagement of vertex presentations, namely, that the lowermost point be at the level of the ischial spines, is not true for face presentations, as the distance from the parietal eminences to the face is greater than to the occiput. Thus the face must descend con-

siderably below the level of the ischial spines before we may conclude that the trachelobregmatic and biparietal diameters have passed the superior strait.

The mechanism of both anterior and posterior mentum presentations is analogous to that of vertex presentations, with the mentum instead of the occiput as the point of reference.

Three possible abnormalities in this mechanism were first described by Hirst:

1. Internal rotation may be delayed, due to mechanical difficulty, as the chin must descend to a lower level before meeting the necessary soft tissue resistance. The fetal neck must stretch, as its length is normally less than one-half the depth of the anterior pelvis.

2. Delivery is mechanically impossible with posterior rotation of the chin to the hollow of the sacrum when the depth of the pelvis is 30 per cent greater than anteriorly.

3. Posteriorly displaced arms into the cavity of the extended back of the fetus greatly impede its progress.

Molding occurs with the usual shortening of the engaging diameter, here the trachelobregmatic, with compensatory lengthening of the directional diameter, the occipitofrontal. The caput succedaneum occurs over most of the face (or forehead in a brow) and is pronounced, especially in posterior mentum presentations.

Almost 2 of 3, or 64.4 per cent, of all face presentations in this series delivered spontaneously. More than 3 of 4 cases, or 76.4 per cent, recorded as mentum anterior or transverse delivered spontaneously, while more than 1 of every 3, or 35 per cent, diagnosed as posterior mentum presentations were spontaneous deliveries.

The mechanism of a persistent brow presentation is analogous to that of an occiput posterior delivery as such, i.e., "sunny side up," with the root of the nose stemming under the symphysis. Since a wider circumference presents and engages in a brow presentation, spontaneous delivery is not the rule, except with a small fetus or a great uterine force. Much molding must occur before even engagement. The engaging diameter (the occipitofrontal) is diminished, while the directional diameter increases. Because of the extensive

TABLE I.—POSITION OF FETUS AT TIME OF DIAGNOSIS IN FACE AND PERSISTENT BROW PRESENTATIONS

A. Face presentations	Point of reference			Total
	Right	Left	Not stated	
Mentum anterior		22		44
Mentum transverse	6			
Mentum posterior	16			16
Total face presentations	22	22	3	47*
B. Brow presentations				
Incipit anterior				
Incipit transverse				
Incipit posterior				
Total brow presentations				0

\*In addition, there were 12 face and brow presentations, recorded simply as face and brow respectively bringing the grand totals to 59 face and 12 brow presentations (see cases).

prerequisite molding dystocia is common and because of the necessarily great uterine force deep perineal lacerations usually result. However flexion to a vertex or extension to a face usually takes place.

In this series, there were only three babies, all of them small who were delivered spontaneously.

The incidence of the various positions as recorded at the time of diagnosis is shown in Table I from which it will be seen that the ratio of face to brow presentations was 87 to 13 or 6.7 to 1. The point of reference which was given in 80 cases was on the right in 41 (39 face and 2 brow) on the left in 39 (33 face and 6 brow) and not recorded in the remainder. At the time of diagnosis, the trachelobregmatic diameter lay in the right oblique of the pelvis in 46 cases in the left oblique in 20 in the transverse of the pelvis in 14 and was unclassified in 20.

#### CLINICAL COURSE

The first stage of labor is definitely prolonged. In this series, the average duration for anterior and transverse mentum cases at term was 23 hours, 8 minutes for primiparas and 21 hours 20 minutes for multiparas and for posterior mentum cases 36 hours 4 minutes, for primiparas and 31 hours, 5 minutes, for multiparas. These figures con-

frast with the accepted average duration of the first stage in vertex presentations, which is 16 hours for primiparas and 12 hours for multiparas.

The factors prolonging the first stage are generally believed to be the remodeling of the face bones which are feeble dilators the dissipation of some of the uterine force in the wrong direction, due to the angle between the head and neck and the delay in internal rotation resulting from the necessity of the chin's descending to a lower level before meeting sufficient soft tissue resistance.

The membranes tend to rupture early. Among 47 cases, they ruptured before or in early labor in 21 cases, just before or at the onset of the second stage in 21 and well into the second stage in 15. The average time for rupture of the membranes in vertex presentations is believed to be at the onset of the second stage.

Among full term deliveries it was interesting to observe that in 9 cases (7 anterior or transverse and 2 posterior mentum) in which the membranes ruptured before or soon after the onset of labor the average duration of the first stage was 26 hours, 26 minutes. In 6 cases (5 anterior or transverse and 1 posterior mentum) in which rupture took place in the mid-first stage the duration was 22 hours, 30 minutes. In 15 cases in which the membranes broke in the second or late first stage the average duration of the first stage was 9 hours, 55 minutes.

Although the cases here cited are not sufficient for statistical proof they do indicate a tendency toward early rupture of the membranes which contrary to its effect in vertex presentations, is probably a factor in the prolongation of the first stage in face presentations.

#### DIAGNOSIS

The classical criteria for the diagnosis of face and brow presentations are usually given as follows:

1. Before labor on abdominal palpation. The cephalic prominence is marked on the same side as the os uteri in a face while equally palpable on both sides in a brow presentation.

2 The presenting part is high In brow presentations an unusually large mass of head is felt above the pelvis

3 A large groove is felt between the back and the occiput

4 The dorsum is concave and is felt distinctly only in the neighborhood of the breech

5 The fetal small parts are unusually easy to palpate, especially in anterior positions of the presenting part

6 DeLee's "triangular area" is not felt

7 The fetal heart sounds are loud and are heard below the umbilicus and usually on the same side as the fetal limbs

8 The uterine ovoid is unusually longitudinal and long

In reviewing the cases in this series and in drawing from their own experience, the authors were impressed by the difficulty of diagnosis solely on abdominal palpation, and especially by the inconsistency of the position of the cephalic prominence in relation to the dorsum The most reliable of the above criteria was the unusually long and longitudinal ovoid shape of the uterus

*B Early after the onset of labor* Diagnosis is supposedly easy on vaginal or rectal examination within a short time after the rupture of the membranes The characteristic landmarks are the orbits, the mouth and gums (the anal orifice grips the examining finger), and the nares

In this series a fair degree of success was achieved in diagnosis at this stage

*C Late in labor* If several hours have passed since the membranes have ruptured, the large caput succedaneum so modifies the face that it may be mistaken for a breech The examiner feels an irregular surface, with prominences and depressions, unlike a vertex The distinguishing features are the saddle of the nose and the mouth and gums, as has been noted, the anus grips the finger

The time and means of diagnosis in 54 cases in this series are given in Table II In this table, the roentgen-ray diagnoses, but not the confirmations, are included in the totals Only 2 cases, or 3.8 per cent, were suspected on abdominal palpation, while 17 cases, one-third, were diagnosed or suspected on rectal or vaginal examination during the first stage

TABLE II—TIME AND MEANS OF DIAGNOSIS OF 54 CASES OF FACE AND PERSISTENT BROW PRESENTATIONS

Means	Time				
	Before onset of labor	First stage	Second stage	On delivery table	Presenting part at vulva or on delivery
Suspected on abdominal	1	1			
Rectal		11	5		
Vaginal		6	6	4	16
Roentgen ray					
Confirmation	1	5			
Diagnosis		4			
Total Time of suspicion	1*	22*	11	4	16

\*Roentgen ray diagnoses but not confirmations are included in the totals.

Thirty-four cases, or 62 per cent, were diagnosed before the patient was placed on the delivery table One case, which was not recognized until spontaneous delivery, had been diagnosed as a breech on vaginal examination during the first stage

#### PROGNOSIS

*A Maternal* A less favorable maternal prognosis in face and brow than in vertex presentations may be expected for the following reasons (1) Longer duration of labor, (2) greater frequency of perineal tears Protrusion and stretching of the perineum occur because of the increased depth to which the presenting part, the chin, must descend before it may impinge against the maternal symphysis, (3) greater danger of infection, (4) frequency of necessary and unnecessary interference

Thus, while maternal mortality is less than 1 per cent in vertex presentations, it may rise to as high as 6 per cent in face presentations In this entire series of 100 cases, there were 3 deaths, or a mortality rate of 3.0 per cent This figure includes 1 death among 87 face presentations (a mortality rate of 1.15 per cent, or 159 deaths per 10,000 live births), and 2 deaths among 13 persistent brow presentations (a rate of 15.4 per cent, or 2222 deaths per 10,000 live births), contrasted with



TABLE III—MANAGEMENT OF 100 CASES OF FACE AND PERSISTENT BROW PRESENTATIONS

Management	Result						
	Full term				Premature		Total births
	Live births	Stillbirths or neonatal deaths	Craniotomy	Monsters	Live births	Stillbirths or neonatal deaths	
A. Face presentations	47		2				49
Vaginal							18
Cesarean	1						
Clashed							
Manual rotation plus DeLee							
Simmons							
DeLee							
Rotation with DeLee							
Total face presentations	48						49
Brow presentations							
Vaginal							
Cesarean							
Clashed							
Total brow presentations							
Total	49	12			2	4	109

a maternal mortality rate of 1.1 per cent, or 131 deaths per 10,000 live births for the entire service in 1932 (10).

One fatal case occurred in 1928 from a ruptured uterus following a version on a right sindput transverse complicated by a Bandl's contraction ring. Delivery was concluded with a craniotomy and manual removal of the placenta. Another death had taken place in 1922 in an eclamptic with the fetus in the right mentum anterior position. Labor was induced and resulted in a stillbirth. The mother died of lobar pneumonia. The third death in 1933 was that of an 18 year old primipara with pre-eclampsia and a conjugata vera equal to 8.5 centimeters. The fetus was in the left sindput anterior position. Thirty five hours after the onset of labor and 2 hours after the rupture of the membranes, a cesarean section with peritoneal exclusion was performed. Death occurred 5 days later from staphylococcus septicemia. The postmortem examination revealed generalized peritonitis with intestinal obstruction, cloudy swelling of

the spleen, liver and kidneys and a post partum uterus.

This series did not show so large a percentage of lacerations or infections as might have been expected. There were recorded 1 cervical laceration into the left fornix, 11 episiotomies, 8 second degree lacerations and 8 first degree lacerations. Some type of infection was observed in 13 cases, 1 of these was a generalized peritonitis resulting in death, and 2 were lobar pneumonia, of which 1 was fatal.

**B Infant.** The following explanations have been offered for the increased infant mortality in face and persistent brow presentations: (1) delayed labor with dystocia, especially in persistent brow presentations; (2) cerebral compression; (3) compression of the neck against the pubis which interferes with the return circulation from the head; (4) great elongation of the neck in posterior mentum positions before the chin can reach the level necessary for rotation; (5) compression of the trachea and larynx against the

TABLE IV—RESULTS OF 84 CASES OF FACE AND PERSISTENT BROW PRESENTATIONS ACCORDING TO PARITY

	Full term					Premature			Total
	Normal live births		Stillbirths or neonatal deaths		Monsters	Normal live births	Stillbirths or neonatal deaths	Monsters	
	Vaginal delivery	Cesarean section	Vaginal delivery	Cesarean section					
Primiparas	1	4	3	0	1	1	3	3	5
Multiparas	42	1	0	0	1	4	2	0	59
Total	43	5	3	0	2	5	5	3	84

pubis with suffocation or even rupture, (6) injury from the use of forceps or other operative procedures, (7) trauma to the eyes by careless vaginal examination (8) impaction in posterior positions if the chin rotates to the hollow of the sacrum. A live child cannot be delivered from below.

In Table III the results of the 100 cases in this series may be seen. The corrected total infant mortality is defined as the percentage of nondeformed children born at term that were either stillbirths or neonatal deaths within 10 days. The corrected immediate infant mortality is defined identically, except that it excludes neonatal deaths. Thus in this series the corrected total infant mortality was 17 of 86, or 19.8 per cent, for face presentations alone it was 15 of 76 or 19.6 per cent, for persistent brow presentations alone it was 2 of 10, or 20 per cent. The corrected immediate infant mortality for face presentations was 13 of 74, or 17.6 per cent. The usually quoted infant mortality rate for face presentations is about 14 per cent (4), although Markoe found as high as 20 per cent. For persistent brow presentations Irving reports an infant mortality rate of 50 per cent.

In our series, one fracture of the left humerus after a version was recorded.

For posterior mentum presentations, a maternal mortality of 0 per cent was accompanied by a corrected total infant mortality of 16.7 per cent, but only 15.8 per cent for the uncorrected infant mortality rate. These figures are even less than our total corrected infant mortality for all face presentations (18.3 per cent). However, the deviation is not statistically significant, as it is a chance variation. These statistics contrast strongly

with Reed's findings of an infant mortality rate of 40.6 per cent for posterior mentum presentations and a corresponding maternal mortality of 11.6 per cent.

Five of 100, or 5.0 per cent, of all the cases were monsters, a predisposing factor (anencephaly, meningocele, etc.). They comprised 25 per cent of the premature deliveries (3 of 12) but only 2.5 per cent of the full term deliveries (2 of 88), they were 4.6 per cent of the face and 7.7 per cent of the persistent brow deliveries.

The results of 84 cases according to parity are given in Table IV, which shows that there was a 20 per cent infant mortality among the primiparas delivering nondeformed full term children vaginally, and a 17.6 per cent infant mortality among the corresponding group of multiparas. Due to the small number of cases the deviation is not statistically significant.

#### TREATMENT

The usually accepted principles regarding the management of and the techniques employed in face and persistent brow presentations may be summarized as follows:

##### 1. General Principles of Management

1. *Mentum anterior and transverse.* Most authorities believe that since anterior and transverse mentum presentations all rotate anteriorly, the management of such cases, if recognized early, should be watchful waiting, except of course with a contracted pelvis. We follow the maxim, "If a 'face' is making progress, leave it alone." The high incidence of spontaneous delivery in this series attests to the wisdom of this policy. However, because of the increased maternal and infant

mortality and morbidity and the higher incidence of disproportion and prolonged labor with dystocia and its consequent dangers attached to all face presentations, the authors believe that in cases recognized early especially in primiparas cesarean section should be given greater consideration than heretofore. The exceptions with a dead or deformed child are obvious.

If a policy of watchful waiting is adopted then follow all measures which will preserve the bag of waters namely (1) Have the patient lie on her side and abstain from all bearing-down efforts (2) exercise care during vaginal and rectal examinations (3) some have found it helpful to put a moderately filled bag into the vagina. We have not.

If the head is in transition from vertex to face the patient lies on the side to which the occiput points as this position favors extension. If the face is fully formed the patient lies on the side to which the chin points in order to facilitate descent and anterior rotation.

**2. Mentum posterior.** Before labor deliver by cesarean section. Some authorities prefer to attempt to alter the attitude by Schatz's abdominal maneuver.

After the onset of labor with the head engaged (1) if the cervix is undilated and the maternal and fetal condition good, consider cesarean section, especially if the membranes have ruptured (2) if the cervix is two fingers dilated and the membranes intact or recently ruptured conversion to occiput anterior is feasible by Ziegenspeck's vaginal maneuver plus Schatz's abdominal maneuver (3) if the cervix is fully dilated and the membranes intact or recently ruptured (a) employ conversion to occiput anterior by DeLee's method or by the combined vaginal maneuver of Thorn plus Schatz's abdominal maneuver or (b) try internal podalic version most men prefer to attempt conversion first while others give priority to version (4) if the cervix is fully dilated and the above maneuvers (conversion or version) have failed, or if the obstetrician is of the opinion that too much time has elapsed since the rupture of the membranes he may attempt manual rotation to an anterior mentum.

After the cervix is fully dilated if the head is engaged the authors prefer to employ Kielland forceps with subsequent rotation and delivery their technique will be described. Other possibilities which have been suggested at this stage are cesarean section and conversion or manual rotation under deep anesthesia after the head has been pushed out of the pelvis.

If the head rotates to the hollow of the sacrum most authorities advise pubiotomy or craniotomy depending on the condition of the mother or child. In one case reported by Musso and Walker in which such impaction occurred the child was successfully delivered by Waters' extrapertoneal cesarean section, which these writers believe is especially adapted for delivery of the hyperextended occiput.

**3. Brow presentations.** Early. Although the factors which have resulted in the deflexion of the occiput to a brow are still present, and although with this conversion the vector of the transmitted uterine force shifts anteriorly in relation to the anteroposterior diameter thus shortening the frontal and lengthening the occipital lever arm all of which tends toward further deflexion yet clinically most of these early brow presentations spontaneously flex back to an occiput with descent under the power of the uterine force. The remaining as a rule extend to face presentations. Few remain as persistent brow presentations. Thus the high fetal and maternal mortality rates for persistent brow presentations are greatly decreased for all early brow presentations. For this reason the authors do not advocate cesarean section in brow presentations early in labor unless otherwise indicated. Instead they advise the following: (1) It is best to employ watchful waiting for brow presentations recognized early and to attempt postural conversion to a vertex (2) have the patient lie on the side to which the occiput points, (3) apply a firm abdominal binder with a pad near the occiput. (4) The exception is the instance in which it is preferable to convert to and retain a vertex with Willett's forceps or even a tenaculum until engagement or further dilation of the cervix.



Fig 1



Fig 2



Fig 3

Fig 1 Primary face presentation Anterior posterior view taken 18 hours before onset of labor Left mentum transverse Note extension of head and spine

Fig 2 Primary face presentation Lateral view taken 18 hours before onset of labor Left mentum transverse

Note again the marked extension of the spine and head

Fig 3 Spontaneous conversion of face to vertex Same case 3 hours before onset of labor Right occiput transverse Note the well flexed head and spine. This spontaneous conversion is the reversal of the rule

Late first or early second stage (1) Flex to occiput, (2) If this fails, try internal podalic version

Late second stage Because of the great delay and dystocia, forceps are necessary when a brow presentation is unrecognized until this stage

Fetus impacted in pelvis This occurs when spontaneous delivery is attempted with a very small head Piper (8) suggests pushing the head out of the pelvis under deep anesthesia, after lubrication with green soap, and following with internal podalic version

The classification of the results of the 100 cases according to their treatment is shown in Table III The following observations may be made

1 Among face presentations, cesarean section produced the best results, with no fetal or maternal deaths in 5 cases

2 Among the 4 cases of both face and brow presentation in which Kielland forceps were applied, there were no maternal deaths and only one fetal death, in spite of the fact that these must have progressed well into the second stage before interference

3 Of the 3 persistent brow presentations which delivered spontaneously, one was a monster, one a premature stillbirth, and the third a full term living child

4 Among the 26 cases in which internal podalic version was performed, there were one maternal death and 8 fetal deaths, all among

full term children, 3 of the deaths were the result of craniotomy

5 Almost one-half of the posterior mentum presentations were delivered by internal podalic version, this group comprised three-quarters of the cases in which interference was deemed necessary

6 One manual rotation was succeeded by version

7 One unsuccessful external conversion (probably by Schatz's maneuver) was followed by cesarean section

8 Internal conversion of a posterior mentum to an occiput anterior (probably by Thorn's maneuver) was unsuccessful in 3 cases and was followed in all by successful internal podalic version

These apparently difficult maneuvers have been mastered by some, however In a series of 9 posterior mentum presentations reported by Mussio and Walker, one successful Schatz maneuver before labor was followed by a spontaneous occiput delivery 2 weeks later Thorn's maneuver was successful in 4 of 6 attempts, resulting in 3 spontaneous occiput anterior and one mid-forceps delivery, all the infants survived One Ziegenspeck maneuver resulted in a brow presentation DeLee (2), using his modified technique of conversion, consisting of four steps, claims 23 successful attempts among 25 face presentations and 2 successful attempts among 3 brow presentations

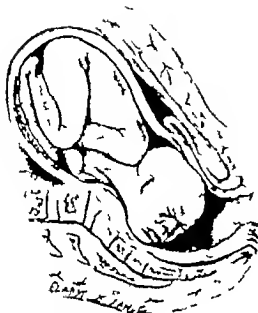


Fig. 4. Face presentation, right mentum posterior

### B Techniques

The various techniques commonly employed are well described in most textbooks, especially the method of conversion, which may also be referred to in the original papers by Schatz, Thorn, and Ziegenspeck and in DeLee's (2) book for his modified technique

so that only a few special points need be mentioned here

1 *Conversion to occiput* DeLee (2) attributes his success to his leading the flexed head into the pelvis applying forceps and then following with a few slight tractions. Titus recommends Willett forceps or a tenaculum over the vertex to maintain flexion, as has been mentioned under the management of early brow presentations

2 *Version* Three difficulties are peculiar to the version of a face or brow presentation: (1) the adaptation of the uterus to the long fetal ellipse; (2) the extreme extension of the back which makes the anterior foot inaccessible; (3) the after-coming head—(a) the great uterine contraction force acting on the hyperextended head makes flexion doubly difficult and (b) the large caput succedaneum over the sinciput may be wedged against the promontory and prevent the aftercoming head from dropping into the hollow of the sacrum

These difficulties may be met with as follows: (1) deep anesthesia and atropine will relax the uterus; (2) flexion of the head and then of the back by pushing in the chest will bring the feet nearer; (3) Piper (9) solves the problem of the aftercoming head by "rotating it with forceps into almost a transverse position thus bringing it into the inlet, after which the forceps may force it into the necessary flexion"



Fig. 5. Manual rotation of the shoulders in right posterior position. The left hand from the right shoulder from the lower uterine segment. With the fingers locked in the axilla and on shoulder the left hand rotates the shoulder clockwise. Rotation of the shoulder facilitates manual rotation of the head

3 *Low forceps (mentum directly anterior)* Forceps are applied in the usual occipito-mental diameter. However, it must be remembered that the mentum is the point of direction which the upper surface of the forceps faces. Therefore, each blade will come to lie in front of the opposite ear instead of in front of the corresponding ear, as in a vertex presentation, i.e., the left blade, held in the operator's left hand, is applied first, this blade goes to the left side of the pelvis and comes to lie in front of the right ear. The facial axis corresponds to the sagittal suture in a vertex presentation. After applying the forceps and before locking them, the operator holds the handles high, to a point 1 centimeter below the level of the mouth, thus allowing the blades to fall into the hollow of the sacrum and permitting a biparietal-malar application in the occipito-mental diameter. He then makes traction downward and increases extension until the chin is delivered from under the symphysis. The direction is now raised so gradually that the exposed trachea will not be injured, extreme flexion delivers the occiput.

It should be emphasized that because of the stretching of the lower uterine segment, rotation, even from an anterior oblique position, should never be attempted by any method but Kielland forceps or manual rotation.

4 *Kielland forceps* The authors are indebted to Dr. Julius Kurzrock for his collaboration in describing the following technique of the application of Kielland forceps to face presentations, as practiced at Harlem Hospital. Kielland forceps are employed only when the face is well engaged.

*Mentum obliquely anterior* As just stated, Kielland forceps are used for anterior face presentations in the oblique diameter as well as in the transverse and posterior diameters. The application of the Kielland to the mentum obliquely anterior is similar to that already described for the application of low forceps to the mentum directly anterior. The blades are again held high before being locked. As in all Kielland deliveries, the handles should never be raised above the horizontal. If delivery has not been effected when this level is reached, the handles are opened slightly, depressed singly to the perineum,

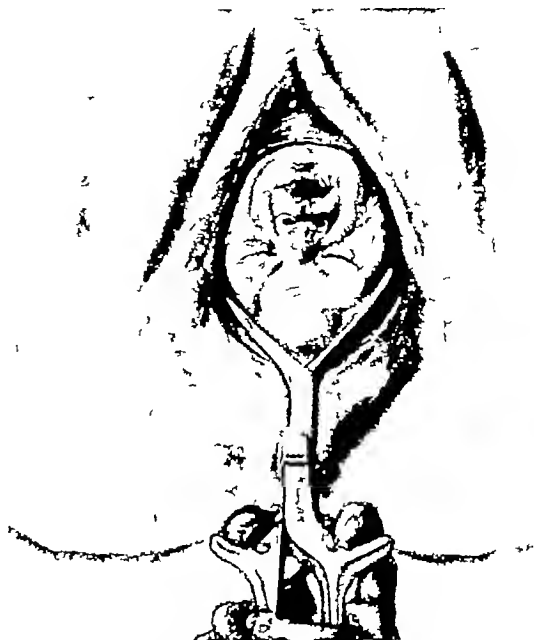


Fig 6 Face presentation. Flexion of the head with the Kielland forceps, after the chin has been stemmed under the symphysis.

locked and again raised to the previous level. This procedure may be repeated until the infant is delivered.

*Mentum transverse* In the mentum transverse position, the authors prefer the Kielland to manual rotation. The usual Kielland inversion method is used. The operator introduces the anterior blade first. In a right mentum transverse the right (male) blade is anterior, and in a left mentum transverse the left (female) blade is anterior. The anterior blade, held like a sword, is inserted along the palm of the vaginal examining hand with the toe of the blade pointing upward and the cephalic surface anterior. The blade is then rotated so that the cephalic (concave) surface rests on the convex surface of the face. This should be done by rotating the blade "in the direction of the button," that is, by allowing the finger guards to follow the button around a semicircle, the blade is thus rotated about an arc of lesser curvature. The operator must exercise great care in the introduction of the anterior blade in order to avoid injury to the stretched lower segment. The posterior blade is then introduced as a shovel along the palm

of the vaginal hand which is applied closely to the face of the fetus. The blades are locked toward the side to which the mentum points; further extension is accomplished by swinging the blades toward the opposite side. The buttons now face the chin. Rotation of 90 degrees is performed so that the buttons and the chin point anteriorly. Delivery is brought about as in a mentum anterior.

*Mentum obliquely posterior.* Because rotation with Kielland forceps is so formidable in the mentum obliquely posterior position, the authors first attempt manual rotation to at least a transverse. If this is impossible, the application is similar to that used in the transverse position except that the axis of the blades in order to correspond to the facial axis, is oblique. The buttons again face the chin, and rotation brings the buttons and chin anterior. It may be easier to insert the blades in this position not directly in the midline but on the side to which the side of the face points, where it is less "crowded." Thus, in a right mentum posterior, right occiput posterior or left mentum anterior position, the anterior blade is inserted just to the maternal right of the midline and the posterior blade just to the maternal left of the midline. In left mentum posterior, left occiput posterior or right mentum anterior positions, the anterior blade is inserted just to the maternal left of the midline while the posterior blade is inserted just to the right of the midline. In transverse positions, mentum or occiput, both blades are inserted in the midline.

*Mentum directly posterior.* In a direct posterior where the chin becomes impacted in the sacrum, spontaneous delivery of a normal sized infant is impossible, as explained under Mechanism.

Mechanism. It may however be feasible to rotate with Kiellands to a deliverable position. The right (male or lockless) blade held in the left hand is introduced first to the left side of the pelvis; the left (female or locked) blade is then held with the right hand and introduced to the right side of the pelvis anterior to the first blade in order to avoid crossing handles when the blades are locked. It is often necessary to push the head slightly upward to facilitate rotation. The operator must bring about rotation slowly and de-

liberately, maintaining extension of the face throughout the operation until the chin is brought under the symphysis pubis. External traction is then accomplished as described above for mentum anterior.

*5. Manual rotation.* Manual rotation of the head is usually facilitated by previous rotation of the shoulders, by locking the fingers in the axilla after freeing them from the lower uterine segment. Rotation of the head is accelerated by abdominal pressure on the occiput by the assistant.

#### SUMMARY

1. Eighty-seven face and 13 persistent brow presentations were found among 46,058 deliveries at Harlem Hospital, New York from January 1, 1914, through June 20, 1943. There was a relative frequency of 6.7 face presentations to 1 persistent brow presentation, a gross incidence of 1 face presentation among 529 deliveries and 1 persistent brow presentation among 3,543 deliveries and a total incidence of 1 in 461 deliveries, either face or brow.

2. Among 79 cases, some etiologic factor was found in 46 or 58.2 per cent. At least borderline disproportion (contracted pelvis or a child weighing more than 8½ pounds) was present in 29 cases, or 63.5 per cent of all cases in which some etiologic factor was found. All cases of face presentation therefore require careful roentgen pelvimetry.

3. Other etiologic factors found in this series were coils of cord around the neck, hydramnios, placenta previa and low implantation, external cephalic version, and fetal monstrosities such as anencephaly, meningocele and dolichocephaly. All causes except coils of cord around the neck can be confirmed or eliminated by roentgenography.

4. Two face presentations occurred subsequent to external cephalic version.

5. The average birth weight among 64 full term children in this series was 7 pounds, 12.2 ounces, about two-thirds of a pound higher than the average full term newborn child at Harlem Hospital. However, face presentations occurred in 12 premature deliveries.

6. Multiparity was proved statistically to be a predisposing factor in this series. In cases

in which parity was recorded, 72.1 per cent of the mothers were multiparas. This fact is consistent with the higher birth weights among face presentations and the progressively larger babies produced by the same mother in successive pregnancies. The obliquity of the uterine axis to the pelvic inlet resulting from the relaxed abdominal wall in multiparas would predispose only to the formation of posterior mentum presentations from occiput anteriors.

7. Almost 2 of 3 of all face presentations delivered spontaneously, including more than 3 of 4 mentum anterior and transverse and 1 of 3 mentum posterior, but less than 1 of 4 persistent brow presentations (all small babies) delivered spontaneously as such. In mentum anterior and transverse presentations, therefore, provided no disproportion exists, a policy of watchful waiting is followed as long as progress persists.

8. A tendency to early rupture of the membranes was observed and found to be associated with a prolonged first stage. Early rupture of the membranes therefore necessitates both a reconsideration of the planned management and careful roentgen pelvimetry, in the event the latter has been previously neglected.

9. Diagnosis by abdominal palpation was found to be difficult. Roentgenography was employed in only the most recent cases. In 4 cases the diagnosis was made solely in this manner, while in 6 others a roentgenogram confirmed the face or brow presentation previously suspected.

10. A maternal mortality rate of 1.15 per cent among 87 face presentations and of 15.4 per cent among 13 persistent brow presentations, or a combined rate of 3.0 per cent, was recorded; maternal morbidity was not markedly increased.

11. Of the full term nondeformed children, 19.6 per cent of the face and 20 per cent of the persistent brow presentations were stillbirths or neonatal deaths within 24 hours, a combined mortality rate of 19.8 per cent.

12. Five per cent of all the children in this group were monsters, these comprised 25 per cent of all premature deliveries, but only 2.3 per cent of full term deliveries.

13. Among 5 cesarean sections performed on face presentations, there were no fetal or maternal deaths. One peritoneal excision cesarean on a brow presentation after 35 hours of labor and 2 hours of ruptured membranes resulted in death from generalized peritonitis and septicemia.

14. The technique followed for the application, rotation, and extraction of face presentations with Kielland forceps is described.

#### CONCLUSIONS

1. Abdominal palpation is unreliable as a means of diagnosis of face presentations, especially the classical criterion of the relative position of the cephalic prominence.

2. Because of the high frequency of disproportion as a predisposing factor toward face and brow presentations, the early use of the roentgen-ray, especially with pelvimetry, is strongly advocated.

3. Because of the higher maternal and fetal morbidity and mortality and the greater incidence of disproportion and prolonged labor with dystocia accompanying extension of the head, cesarean section should be given greater consideration than heretofore in early diagnosed cases of face presentations, especially in primiparas.

4. The predisposing factors of multiparity and large babies to face presentations are thought to be directly correlated in view of the fact of the increasing birth weights of babies born in succeeding pregnancies to the same mother.

5. The high percentage of uneventful spontaneous deliveries among face presentations is sufficient grounds for our maxim, in the absence of disproportion: "If a 'face' is making progress, leave it alone."

6. A case "type" has been found and is presented for serious consideration. A multipara enters the hospital at term in very early labor because of ruptured membranes. Although her previous children were much smaller, the large baby is not considered significant, because of the multiparity of the mother. The face presentation is usually not recognized. A prolonged, morbid labor results from the cephalopelvic disproportion, complicated by a face presentation and early



ruptured membranes. A difficult vaginal delivery perhaps by axis traction forceps, results in a stillbirth or neonatal death and a morbid patient in poor condition. A cesarean section should have been preferred despite multiparity.

## REFERENCES

- DeLee, J. B. *The Principles and Practice of Obstetrics*. P. 677 7th ed. Philadelphia W. B. Saunders, 1930.
1. Ibid. pp. 55-54.
2. Hirst B. C. *A Text-book of Obstetrics*. Pp. 240-42 8th ed. Philadelphia W. B. Saunders, 1918.
3. Lavin, F. C. *A Textbook of Obstetrics for Students and Practitioners*. P. 340 New York Macmillan 1934.
4. Makror, J. W. *Bull. Lying in Hosp.* N. York, 1909, 6, 5.
5. Mirazo, J. C. and W. Lutz, H. L. *Am. J. Obst.* 1914, 4, 88-9.
6. Puyard, A. *Traité du palper abdominal au point d'ue obstétrical et de la crase par manœuvres externes*. Pp. 32-39, 2d ed. Paris G. Steinheil, 1899.
7. Pyle, L. B. *Anomalies of the passage*. J. Curran, 4th Ed. *Obstetrics and Gynecology*. Vol. IV. Pp. 14-16, 33-34 Philadelphia W. B. Saunders, 1913.
8. Ibid. p. 1.
9. Fowler, A. C. and P. H. M. *Am. J. Obst.* 1935, 30, 357-362.
10. Rizzo, L. B. *Am. J. Obst.* N. Y. 1935, 5, 65-635.
11. Scott, F. *Arch. Gyn.* 1912, 5, 306-311.
12. Scott, E. A. *A Textbook of Obstetrics*. P. 49 Philadelphia W. B. Saunders, 1916.
13. Tarn, R. *Zach. Geburtsh. Gyn.* 1914, 3, 95-105.
14. Tarn, R. *Monat. Ber. Verh. Lohr. F.* 1907, No. 134 (Gyn.). 3, 745-770.
15. Tarn, P. *The Management of Obstetric Difficulties*. P. 44 81 Louis. C. V. Mosby, 1917.
16. Turner, L. H. *Practical Obstetrics*. P. 342, 6th ed. Ed. 1st and largely rewritten by Bethel Holmstrom London Humphrey Milford (Oxford University Press) 1919.
17. W. Tiers, E. C. *Am. J. Obst.* 1910, 9, 1-131.
18. Williams, J. W. *Obstetrics A Textbook for the Use of Students and Practitioners*. P. 359, 6th ed. New York Appleton, 1913.
19. Ibid. p. 317.
20. Ziff, R. *Samuel Klin. Verh.* N. Y. (Gyn.) No. 80. Leipzig, 1896, pp. 2067-2068.

# ONE ASPECT OF THE POST TRAUMATIC SYNDROME IN CRANIOCEPHAL INJURIES

KENNETH G. McKENZIE Toronto, Canada

**T**HE purpose of this paper is to present a hypothesis the acceptance of which helps prevent and cure, in a sizable number of patients, the posttraumatic syndrome of headache, dizziness, and mental and physical fatigue. It is applicable to civil and military practice and so justifies mention today.

Briefly the hypothesis is this: An injured and therefore unstable vasomotor system incapable of quickly supplying blood to the brain is the cause of the symptoms of dizziness, light-headedness, blackouts, headaches, and mental and physical fatigue in at least some patients. If this be true one should take steps to restore the function of the injured vasomotor centers as soon as possible and so prevent a train of symptoms which have an organic basis but may, as the weeks go by, become clouded by a functional superstructure.

This idea (1) developed and became useful to us some 6 years ago after observing the following patient: A young adult, well developed and accustomed to heavy work, was referred for an opinion because of incapacitating headache and dizziness. Some 6 months before he had been unconscious for about one-half hour following a head injury. He was kept flat in bed for 8 or 10 weeks, then was allowed to be up. Incapacitating dizziness and some headache had persisted after he was allowed to be up.

Examination disclosed that this patient's dizziness was really a faintness, light-headedness, or mild blackout, brought on when he changed from the horizontal to the erect posture. This was readily explained by his inadequate vasomotor system. In the horizontal position the systolic pressure was 120—on standing the patient's pulse disappeared at the wrist; he became white, and he would nearly

faint. A few moments after standing erect the patient's pulse could be felt returning and he would straighten up and feel better. However, any sudden movement would bring on the syndrome in a milder degree. Not having received advice this patient had continued to seek the horizontal position in which he was most comfortable, spending all his time lying down. Any position or exercise that might have restored the vasomotor system was avoided as the patient thought that the production of his symptoms in this way was harmful.

The situation was explained to the patient for 3 months he co-operated in a regimen which involved sleeping with the head and shoulders well up—never lying down flat day or night. Stooping exercises were practiced many times a day and tolerance built up for this movement. Also he spent many hours in the open air walking and swimming. In 3 months the systolic pressure responded immediately to a change of posture. All symptoms had disappeared. The patient returned to work without further compensation and has remained well with good morale.

Our interpretation of this case was somewhat as follows: The man's vasomotor centers had been injured along with the rest of the brain—he had been kept flat on his back for some 10 weeks and during this period his injured vasomotor system had adjusted itself to supply blood to the brain in adequate amounts only in the horizontal position—the patient found himself comfortable when lying flat and so spent almost all his time in that position, in this manner never stimulating the vasomotor system to function adequately in the upright position.

This of course was an extreme case, the blood pressure dropping to zero when the upright position was suddenly assumed. We postulated minor degrees of disturbed function in circulation that could not be demonstrated by

the ordinary means of recording blood pressure but yet might account for what the patient called dizziness, headache and mental and physical fatigue.

Largely on the basis of this experience we have for some years advised elevation of the head and shoulders sitting on the edge of the bed and getting up as soon after the injury as possible. This means that most patients are up a few days after a head injury. In general it is felt that early erect posture will more quickly retrain the injured vasomotor system and prevent it from becoming conditioned to the horizontal position and so unable to function adequately when position is changed rapidly. Patients are quickly out of bed after various traumatizing cerebral operations. One fails to see why a very early erect posture and some activity should do anything but improve circulation through cerebral tissue damaged by violence to the skull.

Psychologically too, of course such procedures are valuable, the relatives and other patients see that progress is being made quite a different attitude is produced from that extreme of keeping a patient flat in a dark room with no visitors for weeks on end.

The optimum time to prevent or cure a patient of headache, dizziness, mental and physical fatigue is during this first stay in hospital and not some months later. Keeping patients in hospital is often difficult but an added few weeks of active treatment may save months of disability.

For instance a recent patient was unconscious about 15 minutes, had blood in the cerebrospinal fluid, and for about a week was definitely dull and apathetic. Once or twice the advisability of exploratory burr holes for subdural blood was considered, after about 10 days there were complaints of headache and dizziness on change of posture, there was also a definite interest in compensation. It is reasonably certain if this patient had been sent out of hospital at the end of 2 or 3 weeks he would have been a problem 3 or 4 months later. An active regimen was commenced—he was made to get up when he wanted to lie around in bed, made to shave himself and then gradually persuaded to go to the occupational therapy department. He became inter-

ested in various games which involved stooping such as table tennis, playing checkers on the floor so that he had to stoop to make a move, and various other comparable games. He was also encouraged to do stooping exercises every time the house surgeon or nurse went around to see him. Under this regimen partly psychological and partly physiological he got well in 7 weeks and admitted on discharge that he was ready to go to work and that he was free of headache and dizziness. The case was immediately settled with the insurance company not only to their benefit but more important to the benefit of the patient. One admits that these times make it easier to handle a problem like this because it is so easy for a patient to get a job and he has the stimulus of seeing everybody busy and at work. It is quite definite that the Compensation Board of Ontario is not now having nearly the number of posttraumatic syndromes that they had in hard times, this of course we always suspected but it has been clearly demonstrated during this unusually remunerative period for the manual worker.

This general idea of what one might term convalescent treatment to improve the tone of the vasomotor system is advocated in civilian and military hospitals. One postulates that many patients remain in bed far too long after a head injury and when finally allowed up little or no effort is made to restore their physical and mental well being. Especially is it important to restore the tone of the injured vasomotor centers as early as possible. Facilities for such treatment are as yet inadequate and undeveloped but it is always possible to improvise simple measures and bolster morale with common sense advice. In our experience the best time to help the patient is during the first few weeks after the head injury not some months later.

It is admitted of course that many patients cannot be rehabilitated in a short period. An ideal regimen might be the transfer of these patients, who are obviously not going to be fit in a few weeks to centers with facilities for carrying on a continuous active regimen for months. Thus there should be no prolonged gap between the early active regimen and the stay in special centers. Such centers of course

require adequate specialist personnel, a good occupational therapy department, a gymnasium, and physical instructor, game facilities, etc., and finally rehabilitation facilities to place individuals who have a permanent partial disability.

As yet all this is inadequately developed in civilian practice. In the armed forces the problem may be more efficiently approached and developed.

NOTE This paper was written some six months ago. Further consideration of the problem leads one to feel that early attention to the restoration of vasomotor tone is important, but probably more important is an active regimen instituted by the surgeon to prevent a functional syndrome—so difficult to deal with when once established. Surgeons are prone to pay little attention to this problem which is so important in the case of the patient with a craniocerebral injury.

#### REFERENCE

1. McKENZIE, K. G. Cranio-cerebral injuries. University of Toronto M. J., January and April, 1938.

# THE VALUE OF THE STONE DISSOLVING AGENT SOLUTION C IN THE TREATMENT OF ALKALINE INCRUSTATIONS OF BLADDER LESIONS

CHARLES C. HERGER, M.D. HANS R. SAUER, M.D. and ERWIN METER, M.D.  
Buffalo, New York

THE treatment of urinary infections with persistently alkaline urine represents a difficult problem particularly in patients in whom complicating factors such as necrosis due to ulcer or tumor formation favor development of incrustations and stones. The usual therapeutic procedures consisting of attempts at acidifying the urine by diet and drugs supported by removal of stones and incrustations through the cystoscope are tedious and do not yield satisfactory end-results in a considerable number of cases. Also the administration of various drugs of the sulfonamide group has been of limited value only.

Most commonly encountered in these infections are bacteria of the *Bacillus coli* group. Of these *Bacillus proteus* and *Bacillus pyocyaneus* have particularly marked urea splitting properties causing persistent alkalinity of the urine due to formation of ammonia. While these bacteria grow best in alkaline medium it has been demonstrated that they cannot survive or multiply in urine of pH 4.5 or 4.0 or less (5). It is obvious therefore, that favorable end-results can be accomplished best if one succeeds in decreasing the pH of the urine to bactericidal levels. However such low pH levels can rarely be attained by the use of drugs and diet alone or in combination.

Attempts have been made in the past to cure alkaline cystitis by repeated irrigation of the bladder with various acid solutions. The results accomplished with weak solutions of acetic or phosphoric acid were discouraging as a rule because inorganic acids are poorly tolerated by the bladder mucosa. A more favorable response was obtained by Wilhelm and Levine who treated 9 patients by repeated instillations of citric acid sodium citrate solution at 30 minute intervals. However Wilhelm and Levine emphasized that bladder irritation of considerable degree developed in several instances which required local application of novocain

and opiates by mouth during the course of treatment.

Recent investigations by Seby, Seby and Albright (3) have confirmed the irritating effect of citric acid sodium citrate solution on the bladder mucosa. While investigating the effect of various acid test solutions on the bladder mucosa in rabbits for the purpose of finding a stone dissolving agent they found that lavaging the rabbit bladder with a citric acid sodium citrate solution of pH 4.0 caused hematuria after 15 minutes. Continued lavage for 4 hours produced complete destruction of the epithelium as well as edema and hemorrhages involving the entire bladder wall. Seby, Seby and Albright found after long and thorough experimentation that the irritating effect of citric acid sodium citrate solution could be practically eliminated by addition of magnesium oxide without impairing the stone dissolving properties of citric acid. This solution, which is referred to by these investigators as "solution G" has a pH of 4.0 and is composed as follows: citric acid (monohydrate) 32.3 grams, magnesium oxide (anhydrous) 3.8 grams, sodium carbonate (anhydrous) 4.4 grams, distilled water ad 1000 cubic centimeters.

Seby, Seby, and Albright found that continuous irrigation of the bladder in rabbits with solution G for 4 hours produced no gross damage to the mucosa, and only slight edema of the bladder wall was found on microscopic examination. Clinical investigations by these authors revealed that solution G is well tolerated by the mucosal lining of the human urinary tract and that alkaline stones could be dissolved with this solution without producing ill effects. Seby and collaborators were able to accomplish favorable results from the use of solution G in 20 patients with inorganic calculi, and they demonstrated that even large staghorn stones were dissolved completely after continuous irrigation for 40 days. Thus Seby, Seby and Albright have brought the problem of dissolving inorganic stones of the urinary tract considerably nearer to its solution (2, 3).

From the Urological Department of the New York State Institute for the Study of Malignant Diseases, and the University of Buffalo, School of Medicine and the Children's Hospital, Buffalo, N. Y.

# HERGER ET AL SOLUTION G IN BLADDER LESIONS

The bactericidal action of solution G has been investigated recently by Sauer and Neter who found that solution G produced bactericidal effects within 24 to 72 hours at 37 degrees C against strains of *Bacillus coli*, *Bacillus proteus*, *Bacillus morganii* and *Streptococcus faecalis*. It was also demonstrated that the admixture of urine to solution G caused an increase in pH coinciding with a decrease in antimicrobial activity against *Bacillus coli*. While an equal mixture of solution G with urine of pH 7.6 produced appreciable bactericidal effects, it was found that a mixture of 75 per cent urine (pH 7.6) and 25 per cent solution G had no appreciable antimicrobial properties.

During the past year we have carried out clinical investigations as to the usefulness of solution G in the treatment of urinary infections which were characterized by persistent alkalinity of the urine with resulting tendency to formation of incrustations and stones. Subjected to treatment were 21 patients who had the following underlying pathological conditions: 13 patients had ulcerations of the bladder to which incrustated slough was adherent, 1 patient had alkaline cystitis with marked tendency to formation of stones and incrustations, 5 patients had necrotic bladder tumors which were covered by alkaline incrustations, and the remaining 2 patients had inorganic stones of the urinary tract.

In carrying out treatment the following method was employed. A three way Foley bag catheter (Foley-Alcock) was placed indwelling and solution G was administered by means of an intravenous clysis outfit at a rate of from 40 to 60 drops per minute. Continuous drainage of the bladder was assured by allowing the mixture of urine and solution to escape through the return tube of the catheter. More recently we have elevated the tube draining the return fluid 20 to 30 centimeters above the symphysis. Thus tidal drainage and periodical distention of the bladder with a mixture of urine and solution G were effected. From 3000 to 4000 cubic centimeters of solution G was used daily and since the 24 hour fluid intake of the patients did not exceed 3000 cubic centimeters it can be assumed that the return fluid contained at least 50 per cent of solution G. In addition regular irrigation of the bladder with solution G was carried out 2 to 3 times daily and urinary antiseptics were administered orally. Cystoscopic re-examinations were usually made at weekly intervals for the purpose of determining whether or not continuation of treatment was indicated. Depending on the response to treatment, irrigation was carried out for a period of from 1 to 4 weeks.

Irrigation of the bladder with solution G was well tolerated in all patients but one. This patient had an incrustated tumor in the vesical neck region, and treatment had to be discontinued after 2 days because of persistent bladder tenesmus. Further observation of this patient revealed that he did not tolerate an indwelling catheter even without the use of solution G, and it can be presumed, therefore, that the irritation was due to the location and character of the primary lesion.

In the remaining 20 patients no appreciable ill effects developed. However, on cystoscopic examination increased injection and thickening of the bladder mucosa were observed in all patients after exposure to solution G for more than 3 weeks. These changes were transient and disappeared spontaneously 1 to 2 weeks after treatment was completed.

In the group of 13 patients with incrustated ulcerations of the bladder, ulcer formation developed after abdominoperineal resection for carcinoma of the rectum in 2 cases. In the remaining 11 cases ulcer formation occurred following radium irradiation for cancer of the cervix in 9 instances and after interstitial radiation for carcinoma of the bladder in 2 instances. None of these 13 patients showed evidence of tumor during and after treatment with solution G. The ulcerations had been present for less than 1 year in 8 cases. In the remaining 5 patients the lesion had persisted from 1 to 2 years in 2 cases, and from 7 to 8 years in 3 cases. Various methods of treatment, such as oral administration of urinary antiseptics, weekly instillations of silver nitrate, and repeated removal of incrustations with the Young rongeur, had been employed in the latter 5 patients prior to irrigation with solution G, but the response to treatment was unsatisfactory in each of these cases.

The following results were accomplished by the use of solution G in this group consisting of 13 patients:

Complete cure with resulting scar formation at the site of the lesion was obtained in 8 cases (61.5 per cent). In 4 of these cases the ulcers had persisted for less than 1 year and in the other 4 patients for 1½, 2, and 7 years (2 cases). Treatment was carried out in 4 cases for 2 weeks and in 4 cases for 3 weeks. Only in 1 patient treatment had to be repeated for a period of 10 days because of recurrent formation of incrustated slough developed 2 months following the first course of treatment. All of these 8 patients are free of symptoms at the time of writing and the urine, persistently alkaline before treatment, has become and remained acid since treatment was commenced.

The effectiveness of this method of treatment is illustrated best in the following case report.

Ch. C. No. 734, a 3-year-old boy, male, admitted to the hospital on May 21, '35, for the treatment of a solid infiltrating carcinoma of the bladder located at the left border of the trigone. Transurethral resection of the tumor followed by implantation of radium as carried out resulting in disappearance of the tumor. However an increased radium slough developed 3 months after treatment. It persisted for more than 7 years in spite of treatment consisting in repeated removal of slough and incrustations as well as urinary antiseptics by mouth. When he returned for re-examination on August 27, '34, he had almost complete urinary retention, severe dysuria and frequency and he was passing bloody urine which contained gravel. The pH of the urine was 7.4. Cystoscopic examination revealed 200 cubic centimeters of turbid residual urine. The bladder was very small and had a capacity of 50 cubic centimeters. The entire trigone was markedly edematous and an area of increased slough covered the left border of the trigone as well. The lesion extended downward to the caliculi sphincter which was completely surrounded by sloughing tissue to which calcareous deposits were adherent. Chemical analysis of the calcareous deposits revealed irregularly amorphous phosphate with some calcium oxalate.

Following cystoscopic examination No. 24 F 50 cubic centimeter 3 y Foley bag catheter was placed indwelling, and drip irrigation of the bladder with solution G was started. Cystoscopic re-examinations were carried out at weekly intervals showing steady improvement in the appearance of the bladder. Treatment was discontinued 4 weeks later on September 4, '35, at which time neither slough nor incrustations were seen on cystoscopic examination. When he returned for re-examination 3 months later (November 4, '35) he was feeling ill and he had no symptoms referable to the genitourinary tract. Cystoscopic examination revealed scar formation at the site of the previous ulceration. It was last examined July 30, '37. He had no dysuria, his urine was clear pH 4.4, the bladder capacity had increased to 150 cubic centimeters and cystoscopic examination showed no pathological condition except for scarring at the left border of the trigone.

The results accomplished in the remaining 5 cases of the group of 13 patients with increased bladder ulcerations were less spectacular although evidence of favorable response to treatment with solution G was apparent. In 4 of these 5 patients treatment resulted in marked relief from symptoms coinciding with disappearance of the calcareous deposits. However in spite of continuous drip irrigation for a period of from 3 to 4 weeks, some sloughing tissue remained adherent to the surface of the ulceration in these 4 cases. In 1 of them recurrent formation of incrustations developed 3 months after treatment was discontinued but these disappeared promptly after a second course of treatment.

It is of interest that these 4 patients were subjected to irrigation with solution G only a short time after radium ulcerations had developed. It must be kept in mind that in such cases healing occurs only after the circulation of the affected

area is re-established. Experience has shown that as a rule considerable time elapses before these prerequisites to cure are fulfilled and months or even years may go by before healing of radium ulcers takes place. In view of these considerations it may be presumed that the use of solution G in these 4 cases was of limited success only because the lesions were too recent. In contrast, it is our impression that the favorable results obtained in patients with ulcerations of long standing are due to the ability of solution G to dissolve incrustations which prevented healing of lesions as repair of the circulation had taken place before treatment with solution G was commenced.

In the last of the 13 patients with increased bladder ulcers treatment had to be discontinued after 1 week because the patient was an epileptic and mentally unbalanced. Appreciable regression in the amount of calcareous deposits occurred following the use of solution G although improvement was of short duration only.

Continuous drip irrigation with solution G was employed in 5 patients with carcinoma of the bladder. Four of them had papillary infiltrating tumors and 1 had a solid infiltrating carcinoma. All of these cases had persistently alkaline urine and the tumor was covered by incrustations which caused considerable discomfort to the patient and prevented successful employment of endocervical methods of treatment.

Disappearance of the calcareous deposits coinciding with a change of the urine from alkaline to acid pH levels took place in 4 of these cases. Treatment yielded no results in 1 patient who did not tolerate an indwelling catheter. It is obvious that the ultimate outcome in the 4 patients who responded favorably to treatment was and will be determined by the character of the primary lesion. Aside from this consideration we believe that the use of solution G is a valuable adjunct in the treatment of such cases because dissolving of incrustations and gravel will not only improve dysuria and frequency but it will render some of these tumors more suitable for treatment.

We had the opportunity to investigate the effects of solution G in 1 patient with urinary calculi.

The first of these patients developed stone formation in the right kidney pelvis 1 year following bilateral ureterectomy and total cystectomy for carcinoma of the bladder (Fig. 1). Bacteriological examination of the urine obtained from the right kidney revealed *Bacillus proteus* and *Streptococcus faecalis*. The urine of the left kidney had a pH of 4.5 while the urine from the right kidney was of pH 7.2. In carrying out treatment No. 20 F 3 way 3 cubic centimeter Foley bag catheter was inserted through the ureterostomy at the moderately dilated urinary pelvis and the balloon of the catheter was inflated with 3 cubic centimeters of the 1.

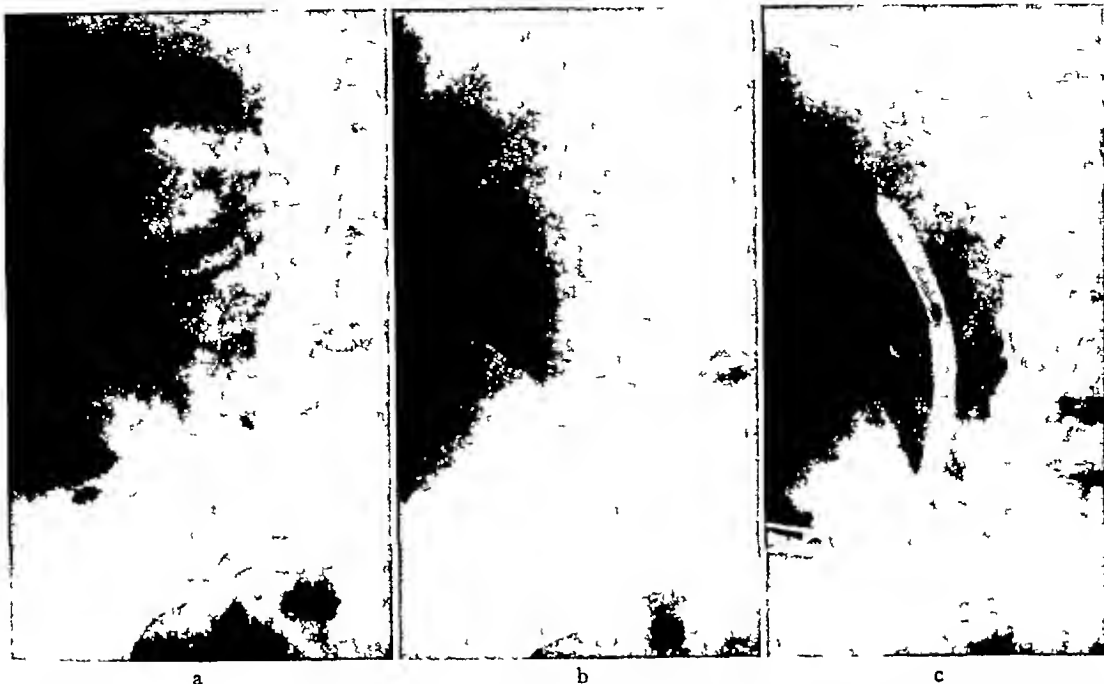


Fig 1 a, X ray film showing stone formation in the right kidney pelvis 1 year after bilateral ureterostomy and total cystectomy for carcinoma of the bladder b, On the 9th day, when treatment was discontinued, the size of the stone

had decreased from 7 to 2.5 millimeters while stone shadow in inferior minor calyx showed no changes c, Roentgenological examination 32 days later revealed complete disappearance of the stone in the kidney pelvis

Continuous drip irrigation with solution G was employed in the usual way for a period of 9 days. Except for slight intermittent hematuria no ill effects developed during and after treatment. X-ray pictures were made twice weekly and it was found that the density of the stone shadow in the kidney pelvis decreased after irrigation for 3 days. On the 9th day, when treatment was discontinued, the size of this stone had decreased from 7 to 2.5 millimeters while the appearance of the stone shadow in the inferior minor calyx showed no changes (Fig 1b). The patient was discharged from the hospital 2 days later and he was instructed to irrigate his right kidney pelvis three times daily with solution G. Roentgenological re-examination 30 days later revealed complete disappearance of the stone in the kidney pelvis (Fig 1c). However, since the stone in the right inferior minor calyx showed no evidence of decrease it may be presumed that the solution did not reach this calculus in sufficient amounts to effect its dissolution. For the purpose of avoiding development of new stones the patient was advised to continue irrigation of the kidney pelvis with solution G and x-ray pictures made repeatedly during the past months showed no evidence of recurrent stone formation up to the time of writing.

The second patient had an adenoma of the prostate complicated by a bladder stone measuring 2.8 by 2.1 centimeters in size. Continuous drip irrigation with solution G was carried out for a period of 3 weeks but the response to treatment was not satisfactory. Only regression in the size of the stone to 1.7 by 1.2 centimeters was accomplished, and, since continuation of treatment was contraindicated because of fever, surgical removal of the stone followed by 2d stage suprapubic prostatectomy was carried out. The

stone proved to be brittle, and chemical analysis revealed that it consisted of magnesium ammonium phosphate.

In addition solution G was employed successfully in the treatment of 1 ambulatory patient with a suprapubic cystostomy for carcinoma of the prostate in whom persistently alkaline urine caused formation of incrustations around the catheter. This patient was instructed to install 50 cubic centimeters of solution G into the bladder 2 to 3 times daily. The urine became and has remained acid 1 week following the use of the solution, and the catheter which prior to that had to be changed at weekly intervals is now being replaced every 4 weeks without showing evidence of incrustations.

In all those patients who were treated by continuous drip irrigation determinations of the pH of the return fluid were carried out at frequent intervals. It was found that the pH of the return fluid varied from 4.5 to 4.9. Such a degree of acidification was attained even in patients whose urine prior to treatment was as alkaline as pH 8.0. These findings indicate that solution G has satisfactory buffer properties. It should be re-emphasized in this connection that sufficiently large amounts of solution G were used to assure that



the return fluid contained at least 30 per cent of the solution.

Complete bacteriological studies, including direct microscopic examination and culture of the urine were carried out in 9 of the 21 patients treated. In 3 patients only 1 micro-organism was discovered. In 3 patients 2 different species. 1 bacteria were present and in 1 patient 3 different bacteria were encountered.

The following organisms were recovered: *Bacillus pyocyaneus*, *Staphylococcus aureus*, *Streptococcus nonhemolyticus*, and *Streptococcus faecalis*, 3 times each; *Bacillus proteus*, *B. coli* coli, anaerobic streptococcus, and *Bacillus funduliformis*, once each.

Bacteriological examinations of the return fluid were carried out every 2d to 3d day. Complete sterilization was not achieved in any of these 9 cases while they were under treatment. However, it was found that treatment resulted in an appreciable reduction in the number of organisms in 5 patients. We are inclined to believe that this reduction in the number of bacteria was, in part at least, due to the radical change of the pH in the contents of the bladder.

In concluding it is our impression that solution G is of value not only as a stone dissolving agent as originally suggested by Suby, Suby and Albright but is of value also in the treatment of urinary infections which are complicated by formation of alkaline incrustations. This method of treatment presents no technical difficulties and it may yield quick and gratifying results in patients who otherwise would have to undergo tedious and at times successful treatment.

#### SUMMARY

Solution G, a citric acid magnesium oxide sodium carbonate solution of pH 4.0 was employed in the treatment of 21 patients who had persistently alkaline urine with tendency to formation of stones and incrustations.

Solution G was administered as a rule by continuous drip irrigation through a 3 way Foley bag catheter for a period of from 1 to 4 weeks. Treatment was well tolerated by all but 1 patient who had an incrustated carcinoma in the region of the vesical sphincter.

The most favorable results were obtained in 13 patients with incrustated bladder ulcerations. Cure with resulting scar formation took place in 8 of these cases, 4 patients showed marked improvement, and 1 patient responded with temporary improvement after treatment for only 1 week.

Disappearance of menstruations was accomplished in 4 of 5 patients with incrustated carcinoma of the bladder.

In 1 patient with urinary calculi treatment resulted in dissolution of 1 of 2 stones in the kidney pelvis and regression in size of the calculus in the other patient.

In addition acidification of the urine was accomplished in 1 patient with suprapubic cystostomy for carcinoma of the prostate.

Complete bacteriological studies were carried out in 9 of the 21 patients treated. Although sterilization of the urine was not achieved in any of these 9 cases it was found that treatment resulted in marked reduction in the number of organisms in 5 cases. Since repeated determinations of the pH of the return fluid yielded invariably pH levels of from 4.5 to 4.9, it is suggested that the reduction in the number of bacteria is due largely to the radical change of the pH effected by this method of treatment.

#### REFERENCES

1. SUTER, H. R., and VETTER, E. J. Urol. 94, 507, 9.
2. SUTER, H. R. and ALBRIGHT, F. J. Urol. 94, 507, 9.
3. SUTER, H. R., SUTER, R. M. and ALBRIGHT, F. J. Urol. 94, 45, 549.
4. WILKINSON, S. F. and LEVINE, B. J. Urol. 94, 47, 570.
5. YEAW, R. C. J. Urol. 94, 45, 609.

# POLYPOID LESIONS OF THE COLON OF CHILDREN

ROGER L J KENNEDY, M S, M D, CLAUDE F DIXON, M D, and  
HARRY M WEBER, M D, Rochester, Minnesota

**I**N most of the articles which deal with the significance of blood in the stools of infants and children, polypoid lesions of the rectum are mentioned as possible sources of the blood. Since the development of proctoscopy, polypoid lesions of the rectum and sigmoid have been demonstrated in an increasingly large number of cases in which the patients are infants and children. However, little emphasis has been placed upon the occurrence, diagnosis, and treatment of noninflammatory polypoid lesions of the colon which are situated beyond the reach of the sigmoidoscope. A realization of the fact that they do occur, with or without concomitant polypoid lesions of the rectum, should lead to more frequent search for them and to their removal.

This paper is based on 11 cases of polypoid lesions of the colon. In all of these cases the patients were children, and the colonic lesions were situated beyond the reach of the sigmoidoscope. Seven of these cases were included in a previous report of 49 cases of polypoid lesions of the rectum and colon which was made by one of us (R K) (4). Because polypoid lesions that are situated beyond the reach of the sigmoidoscope present a special problem, these 7 cases have been included in the present report.

## AGE AND SEX

Of the 11 patients, 4 were girls and 7 were boys. The ages of the patients ranged from 3 to 14 years. The ages of the patients in the individual cases were as follows: 3 years in 3 cases, 4 years in 1 case, 5 years in 1 case, 6 years in 1 case, 7 years in 2 cases, 9 years in 1 case, 10 years in 1 case, and 14 years in 1 case.

## SYMPTOMS

Symptoms had been present for 10 days to 7 years before the patients were brought to the Mayo Clinic. The duration of symptoms in the individual cases was as follows: 10 days in 1 case, 6 weeks in 1 case, 5 months in 1 case, 14 months in 1 case, 2 years in 2 cases, 2½ years in 1 case, 4 years in 1 case, 5 years in 1 case, and 7 years in 1 case. In other words, the duration of symp-

toms varied greatly. The symptoms had been present for less than a year in only 3 of the cases.

Blood in the stools was the outstanding symptom. It was present in all of the cases. In 8 of the 11 cases the amount of blood in the stool never had exceeded 1 fluid drachm (4 cc). The blood appeared on the outside of a formed stool or at the end of the stool. Clotted blood was observed in 4 cases. In 1 case the loss of blood had been sufficient to necessitate transfusion. In this case, two transfusions had been given before the patient was brought to the clinic. The blood appeared in the stools at various intervals. In most cases it was observed at intervals of 1 day to a week but in 2 cases it occurred at intervals of 1 week to several months.

Small amounts of clear or blood-tinged mucus were observed in 5 cases. In 2 of these cases the amount was considerable. A moderate amount of mucus was observed in 2 additional cases. In the remaining 4 cases, mucus either was not observed or no mention was made of its presence.

Pain is not a prominent symptom of polypoid lesions of the colon. In 7 of the 11 cases, there was no history of pain. In 1 case, pain had occurred frequently. One patient occasionally had had periumbilical discomfort which had been relieved by enemas. In 1 case, discomfort had occurred in the left side of the abdomen, and in another case, the patient had had dull, intermittent pain in the left side of the abdomen for 4 days prior to examination at the clinic.

Diarrhea was present in only 1 of the cases. This symptom is of importance in the differential diagnosis of some of the other diseases that have sometimes been confused with polypoid lesions of the colon.

Polypoid lesions of the colon frequently are associated with similar lesions of the rectum. In 2 of the 11 cases, a mass protruding from the rectum was one of the presenting symptoms. In 1 of the 2 cases, a diagnosis of hemorrhoids had been made and the true nature of the lesion had not been suspected.

## DIAGNOSIS

In the diagnosis of polypoid lesions of the colon, the history is of great assistance. The bleeding

From the Section on Pediatrics, Division of Surgery and the Section on Roentgenology, Mayo Clinic.



Fig. 2. a, left, Roentgenogram made after evacuation of the contrast (barium) enema, showing widening in the transverse limb of the hepatic flexure caused by a large polypoid lesion in this segment. b, "double contrast" roentgenogram showing the globular polypoid lesion projecting into the lumen of the colon.



Fig. 3, left. Gross appearance of the polypoid lesion of the colon.

Fig. 4. Photomicrograph of polypoid lesion: adenocarcinoma, grade 1.  $\times 85$ .

has certain characteristics. In the first place, the blood is fresh, that is, it is red in color. This indicates that the source of the bleeding is in the lower part of the gastrointestinal tract certainly below the ileocecal valve. In the second place, the blood usually is on the outside of the stool and is not mixed with the stool as it usually is in cases in which the bleeding is due to lesions of the small intestine such as Meckel's diverticulum. Finally the bleeding is not associated with diarrhea, as it is in cases of chronic ulcerative colitis. On the contrary the stools as a general rule are formed and the patient in many instances even may be constipated.

Symptoms other than bleeding from the intestine usually are strikingly absent. Pain, with or without tenderness, which may be present in cases of Meckel's diverticulum or colitis, is either slight in degree or absent. Patients who have polypoid lesions of the colon usually are well nourished or show no evidence of nutritional disturbance as a result of the disease. This is in striking contrast to the condition that obtains in chronic ulcerative colitis (2) or in amebic colitis (3) which is comparatively rare. Secondary anemia, which occurred only once in this series of cases, is the rule in colitis, especially in chronic ulcerative colitis of the bacterial type.

It should not be difficult to distinguish polypoid lesions of the colon from hemorrhoids. In cases in which a polypoid lesion also is present in the rectum and protrudes from the anus, the lesion at first may be mistaken for a hemorrhoid, but careful examination of the anus and rectum should permit one to make a correct diagnosis of the condition.

#### PROCTOSIGMOIDOSCOPY

In 6 of the 11 cases, polypoid lesions also were present in the rectum. The number of polypoid lesions revealed by proctosigmoidoscopy was as follows: 1 in 2 cases, 3 in 1 case, 4 in 1 case, 7 in 1 case and 8 in 1 case. The diagnosis of the polypoid lesions that were situated beyond the reach of the sigmoidoscope was made by roentgenologic examination. The discovery of polypoid lesions in the rectum is an indication rather than a contraindication for a roentgenologic search for polypoid lesions situated higher in the colon. If, in the 6 cases in which proctosigmoidoscopy revealed polypoid lesions in the rectum, we had confined our diagnostic and therapeutic efforts to these lesions in the rectum, we would have been guilty of gross mismanagement as the bleeding from the polypoid lesions of the colon would have continued.

#### ROENTGENOLOGIC EXAMINATION

Although the presence of polypoid lesions of the colon may be suspected from the clinical history, the diagnosis is made by roentgenologic examination. The number of polypoid lesions of the colon disclosed by roentgenologic examination was as follows: 1 in 9 cases and 3 in 2 cases.

In roentgenologic examinations of the large intestine, the fundamental maneuver is roentgenoscopic observation of the intestine while the contrast medium is being introduced as an enema and after it has been evacuated by defecation. Polypoid lesions are manifested as globular or ovoid filling defects in the cylindrical shadow of the bowel distended with the contrast medium (Figs 1a and b). Since fecal masses can produce such filling defects, all fecal material must be removed from the intestine before the roentgenologic examination is begun.

In all essentials, the roentgenologic examination of the colon of infants and children is conducted in the same manner as it is in the case of adults, and the diagnostic principles are identical. At no time, however, is this examination a simple maneuver, and it can hardly be done without considerable inconvenience and discomfort to the patient. It is usually possible to make adults per-

ceive that their own interests are being served by accepting the transient inconvenience and discomfort with fortitude, such an attitude cannot be expected of a child.

Polypoid lesions, it must be understood, do not deform the contours of the lumen of the intestine as constricting lesions do, but grow as soft, rounded or ovoid excrescences which project into the intestinal lumen. They may produce certain symptoms when they are less than 1 centimeter in diameter, but cause obstructive symptoms only when very large or when they lead to intussusception. When smaller in diameter than is the transverse diameter of the segment of intestine they occupy, they may easily be overlooked in the roentgenologic examination unless precautions are taken: (1) in the matter of preparing the intestine adequately for the roentgenologic examination, and (2) in the actual conduct of the examination.

A satisfactory roentgenologic examination of the colon is out of the question without preliminary removal of all gaseous, liquid, and solid fecal residue. There is no known way of accomplishing this except by the use of purgative drugs, and these must be chosen with the roentgenologic requirements in mind. The large intestine of a child is of proportionally greater length and caliber than is that of an adult. This is one of the circumstances which increases the difficulty of the roentgenologic examination of a child's colon; consequently, nothing in the scheme of preparing the colon should tend to exaggerate this disproportion in length and caliber. Saline purgative agents will act in this manner. They may assist effectively in removing solid fecal residue, but they do it by increasing the fluid bulk of the intestine, thus distending it. The usual net result is that the bowel is in less satisfactory condition for roentgenologic examination than it would have been had no attempt at purgation whatever been made.

To some extent, the same is true of cleansing enemas if enough of them are administered to reduce the fecal content of the intestine effectively. One, therefore, has to rely on the so called irritant cathartic drugs. The emodin and resinous cathartics and those containing phenolphthalein or mercurous chloride are effective enough, but their irritant action is too prolonged if they are administered in doses sufficiently large to promote purgation adequate for the purposes here in mind. The emollient cathartics such as liquid petrolatum and the vegetable oils are unsatisfactory for several reasons, the chief ones being that they are not intense enough in their action and

require too much time before they become effective.

Castor oil remains as the most satisfactory and at the same time the safest purgative agent for the purpose of preparing the large intestine for roentgenologic examination. The response that infants and children make to cathartic agents seems to be even more variable than that made by adults, so the proper dose is determined to some extent by inquiring how an individual child ordinarily responds to these agents. We have found that at least 25 cubic centimeters of castor oil is required for infants and 30 cubic centimeters for older children to promote adequate defecation. When the roentgenologic examination is to be done in the morning, the castor oil is administered the evening before and the evening meal is withheld. The following morning, at least an hour before the roentgenologic examination is begun, a simple enema of not more than 350 cubic centimeters of physiologic salt solution is given to remove the last remaining fecal residue from the rectum and sigmoid colon. The usual morning meal may be given just before the time of the roentgenologic examination.

The first step in the roentgenologic examination is a preliminary survey of the abdominal field and any abnormal appearances are noted. The opaque enema is then administered under roentgenoscopic control, the contrast suspension being studiously observed as it makes the ascent into the upper segments of the colon, including the cecum. The internal topographic features of the bowel are studied by compressing one wall of the bowel upon the other with the palpating hand, and the patient is rotated from side to side on the roentgenoscopic table to bring the entire length of the large intestine into proper projection on the screen. This part of the examination should be done as quickly as possible. The patient becomes uncomfortable if put to mummy and the young patient will surely become the more unruly the longer the time of examination is extended. Furthermore, it is found that the more quickly an enema is administered, the more effectively will it be evacuated when the opportunity is offered. As soon as the roentgenoscopic examination is completed, the child is taken to a toilet and is permitted, even urged, to empty the bowel of the enema as quickly and as completely as possible. The hope is that only enough of the opaque suspension will remain to give the mucous membrane a thin coat of it. Attempts to remove the opaque enema from the intestine by siphonage are usually fruitless, for only that segment actually occupied by the enema tip is emptied, and the patient

thereby loses his stimulus for defecation. It is far better to take advantage of the normal physiologic processes in this connection. Not more than 5 minutes should be allowed the patient to effect this evacuation; however, if the time is extended much beyond this limit dehydration of the opaque suspension will take place, and the barium sulfate will tend to collect in clumps, thus destroying the desired painted effect. The patient is then returned for another roentgenoscopic examination, a special effort being directed at this time to make close scrutiny of the mucous membrane particularly for small irregularities on its surface. Infants and children, as a rule, do not succeed in emptying the intestine enough for institution of a satisfactory double contrast technique. This technique is essentially a roentgenographic one that is, roentgenograms are made after the intestine has been redistended with air or other inert gas, after the contrast enema has been evacuated. It is particularly useful in the roentgenographic demonstration of polypoid lesions (Fig. 1b). If evacuation has been incomplete the bowel is redistended with air anyway and the patient is given another opportunity to expel the enema, now composed of fluid and gas. The patient is returned to the roentgenoscopic room once more, and after a brief examination the intestine is insufflated for the last time and the double contrast roentgenograms are made. Stereoscopic roentgenograms are made by the use of the Potter diaphragm and it is our practice to make them in anteroposterior as well as in posteroanterior projections.

A word about the preparation of the opaque enema might be inserted here. A simple suspension of barium sulfate and water should never be injected into the large intestine. Efficient suspending agents are available but we prefer a commercial preparation of barium sulfate which has a suspending agent already mixed into it and which requires only the addition of water to make the most satisfactory opaque enema known to us. No matter how prepared the opaque enema should be heated to the temperature of the body before it is administered.

When it can be anticipated that a young patient will be unruly and difficult to handle in the roentgenoscopic room, it is well to quiet him with an effective dose of one of the soporific drugs. We have used pentobarbital sodium in doses of  $\frac{1}{2}$  to  $\frac{3}{4}$  grains (0.03 to 0.1 gm.) for this purpose with considerable satisfaction, and it is usually possible to examine even the most refractory child in this way. Here however as well as in connection with the preparation of a young patient for roentgenologic examination, complete co-operation of

pediatrician and roentgenologist is of paramount importance. Opportunities are abundant for the skill of the one to be nullified by the shortsightedness of the other.

#### TREATMENT

The treatment of polypoid lesions of the colon consists of transcolonic excision of the lesions or resection of the involved segment of the colon. The choice of operative procedure depends on the extent of the lesion (1). Umbilication of the wall of the colon usually indicates that the base of the lesion is broad or sessile. In cases in which this is present, segmental resection is indicated. In the majority of cases in which the patients are children, the polypoid lesions have a long pedicle. In such cases, transcolonic excision of the lesion seems sufficiently radical. This operation is performed as a single stage procedure.

In cases in which polypoid lesions of the colon have been disclosed by roentgenologic examination, it occasionally is difficult to locate the lesions by palpation when operation is performed. This is particularly true in cases in which all of the fecal material has not been removed from the intestine before the operation is started. During the past few years, the use of a "cold" light has proved of great value in locating such lesions. The operating room is darkened and the small light is placed behind the colon. This usually makes it easy to distinguish polypoid lesions from particles of fecal material. It permits one to see the small blood vessels of the lesion proper as well as those of the pedicle.

When transcolonic excision is performed, the colon is opened longitudinally on the antimesenteric border. After the polypoid lesion has been excised, the opening is closed by suturing the colon transversely.

As a rule, it is advisable to perform segmental resection in two stages. The first stage consists of resection of the involved segment and the formation of a double-barreled colonic stoma. At the second stage, the colonic stoma is closed. The septum first is crushed with clamps and the stoma subsequently is closed surgically. The closure also may be effected without crushing the septum with clamps.

Transcolonic excision was employed in 9 of the 11 cases. After the lesion had been excised, the pedicle was ligated or cauterized. Segmental resection was employed in 1 case. In this case, a side to side anastomosis was effected. In the remaining case, it was necessary to carry out a resection of the transverse colon and the descending colon.

#### PATHOLOGIC CHANGES

In most cases of polypoid lesions of the colon in which the patients are children, the lesions prove to be adenocarcinomas of a low grade of malignancy (Figs 2 and 3). In a few of these cases, however, the lesion may be found to be a simple adenoma.

In 9 of the 11 cases, microscopic examination disclosed that the lesion was an adenocarcinoma, grade 1 or low grade.<sup>1</sup> In the 2 remaining cases, the lesion was classified as an adenoma. In 1 of these 2 remaining cases, the adenoma was severely inflamed.

Some authors have expressed the opinion that all adenomatous polypoid lesions are potentially malignant and that their removal, therefore, is indicated. Although polypoid lesions may be lipomatous, fibromatous, or angiomatous, we never have observed such lesions in the colon of children. Since the pathologic nature of a polypoid lesion cannot be determined except by microscopic examination, the removal of every polypoid lesion is indicated. Even if the lesion is benign, its presence is undesirable as it can cause intussusception, obstruction, or bleeding.

#### RESULTS

In all of the cases the patients survived the operation and were in good condition when they were dismissed from the hospital. In 1 case, the bleeding recurred 3 weeks after the operation. The patient in this case is still under observation at his home. It will be interesting to learn whether the recurrence of the bleeding is due to ulceration at the site of the operation or to the presence of other polypoid lesions.

#### SUMMARY

Polypoid lesions of the colon are an important cause of intestinal bleeding in cases in which the patients are children. Proctosigmoidoscopy will disclose the presence of polypoid lesions of the rectum and sigmoid colon. In cases in which polypoid lesions of the colon are situated beyond the reach of the sigmoidoscope, the diagnosis must be made by roentgenologic examination although the history usually is significant. In 6 of the 11

<sup>1</sup>In determining the malignancy of neoplasms by the method of Broders all malignant neoplasms are divided into 4 grades—on the fundamental principle of cellular differentiation. In neoplasms that are classified as grade 1 at least 75 per cent of the cells are differentiated or partially differentiated whereas in neoplasms that are classified as grade 4 not more than 25 per cent of the cells are differentiated or partially differentiated.

Since this method of grading malignant neoplasms was devised it has been found necessary to use the term "low grade 1" in designating the degree of malignancy of an adenocarcinoma that occurs in an adenoma. In cases in which the degree of malignancy is classified as "low grade 1" practically all of the cells if not differentiated are at least partially differentiated thereby approaching but not completely imitating the differentiated cells of a strictly benign adenoma.

cases which form the basis of this paper polypoid lesions also were present in the rectum. The discovery of polypoid lesions in the rectum is an indication rather than a contraindication for a roentgenologic search for polypoid lesions situated higher in the colon. The treatment consists of transcolonic excision of the polypoid lesions or resection of the involved segment of the colon. If all of the polypoid lesions can be found and re-

moved, there is little likelihood that they will cause trouble in the future.

## REFERENCES

1. DIXON, C. F. *Proc. Mayo Clin.* 940, 3 09.
2. HILLMAN, H. F. *N. York State J. M.* 926, 26 45.
3. *Ibid.* *Ohio M. J.* 936, 3 94.
4. KENNEDY, R. L. *J. Am. J. Dis. Child.* 84 632-48.
5. SCHMIDT, A. *et al.* *Dent. Zacher Chir.* 917, 202.
6. WEAVER, H. M. *Proc. Mayo Clin.* 936, 3 139.

# THE USE OF METHEDRINE IN SURGICAL OPERATIONS

## Clinical Study on an Effective Pressor Drug

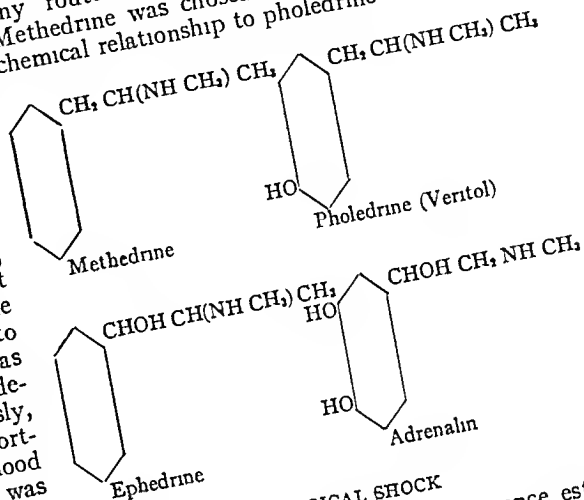
HAROLD DODD, Ch M, F R C S, and FREDERICK PRESCOTT, M Sc, Ph D, A I C, M R C S,  
London, England

SINCE 1932 one of us has studied the use of pressor agents to counteract the serious effects of blood pressure, unaccompanied by severe reduction of blood volume, that often occur during major operations. The pressor effects of adrenalin, ephedrine and pholedrine (veritol) and others have been studied, but it has been found that generally none is effective for more than 30 to 45 minutes during operation, and repeated injections are often necessary.

Although the effect of an injection of 5 to 15 minims of liquor adrenalin (B P) on a patient with a low blood pressure is dramatic and the blood pressure climbs almost instantaneously to 200 to 300 millimeters mercury, the fall is just as precipitate. Similarly ephedrine, which for dependable results must be given intravenously, produces a sharp rise in blood pressure with short-lived effect, about 10 to 20 minutes and the blood pressure falls again. Until 1938, ephedrine was considered the best pressor drug available for counteracting the fall in blood pressure resulting from spinal anesthesia. From 1937 to 1942 one of us used pholedrine as a pressor agent to maintain the blood pressure in major operations. The results were better than with ephedrine in that pholedrine was effective intramuscularly as well as intravenously, but the effect of a single injection of the drug was rarely more than 45 minutes. Repeated injections were often necessary. One of us remarked of pholedrine "Its only weakness is that its effect is not long enough (although it has yet to be shown that any other drugs are better in this respect). May one look for a drug that will restore and maintain a moderate level of blood pressure for two hours or more?" (Dodd, 1939).

We believe that this ideal pressor agent has been found and proved in the recently available drug methedrine.<sup>1</sup> This was examined in a search for an effective pressor agent with a reliable and

sustained action that could be administered by any route under average clinical conditions. Methedrine was chosen on account of its close chemical relationship to pholedrine.



### SURGICAL SHOCK

Surgical shock is so serious that, once established, the outlook is grave. Therefore, every surgical team aims to prevent shock and not to wait until it supervenes and then treat it with transfusions and blood pressure raising drugs, which are probably useless once shock is established. Lord Moynihan said that we should not only make surgery safe for the patient, but we should make the patient safe for surgery. In the light of our experience we think that no major operation should be performed especially under spinal anesthesia, without serial recordings of the blood pressure at least every 10 minutes and preferably every 3 to 5 minutes. We have found that the feel of the pulse is misleading as a guide to the blood pressure. While it will give a rough estimate of the patient's cardiovascular system, we have observed patients repeatedly with a good and regular pulse and the blood pressure between 60 and 80 millimeters systolic or their pulse pressure 10 millimeters or less.

It is taught that as the blood pressure falls the pulse rate goes up and that a progressive rise in

Mr Dodd is surgeon to the King George Hospital Ilford the Royal Hospital Richmond and assistant surgeon to the London Homoeopathic Hospital. Mr Prescott is clinical research director. The Wellcome Foundation London.  
<sup>1</sup>Methedrine is the Burroughs Wellcome & Co trademark for N methylamphetamine the hydrochloride of which was used in this study.



rate is usually a bad sign. In our readings this is by no means true. We have often observed a falling blood pressure to coincide with a falling pulse rate for example systolic 60 millimeters, pulse 40 to 50. The pulse rate alters during an operation in response to the anesthetic or the surgical procedure. The clinical signs of shock at operation are described as pallor, sweating, coldness of the skin, falling blood pressure, rising pulse rate, dilated pupils, and sighing respiration. Some of these (respiration, pupils, sweating, and pallor) are modified by the premedication (morphine, scopolamine, atropine), the anesthetic and the temperature and humidity of the operating theater and therefore are not reliable signs of shock. From a study of a number of operations we consider that incipient shock can best be detected by following the blood pressure and observing the color and temperature of the patient's arm. We regard a fall in blood pressure below 80 millimeters systolic or pulse pressure of less than 30 millimeters and cold extremities (nose, ears, limbs) as signs of impending shock. A pressor drug should be given to restore the blood pressure or a plasma transfusion if there has been a considerable fluid loss. Patients with a low blood pressure and impending shock often have collapsed veins. An efficient pressor drug should therefore be effective intramuscularly as valuable time may be lost in entering a vein. We have found that methedrine has this advantage; it acts intramuscularly in approximately 5 minutes and gradually restores fallen blood pressure to normal in 15 to 18 minutes. We think that this consistent, gradual action is one of its assets.

It is a debatable point to what level the blood pressure should be allowed to fall and how long it may remain down before attempting to raise it to normal levels. Hewer (1943) gives a guide. He states that a patient should not be left on the operating table for more than 30 minutes with a systolic pressure below 80 millimeters, or a diastolic pressure of less than 60 millimeters; that if this time is appreciably exceeded death is extremely probable within 48 hours. A very low blood pressure is inadequate to sustain the vital processes and if prolonged may lead to irreversible shock (McMichael, 1942).

Independently we adopted this as one indication for administering methedrine. We believed that blood pressure below 80 millimeters for any length of time would deprive the heart, brain, and other vital centers of blood and hence of oxygen and nourishment and thus slow recovery, impair healing power and predispose to postoperative complications. We question to what extent are such

postoperative complications as repeated vomiting, dilatation of the stomach, ileus, postoperative pneumonia, embolism, and suppression of urine due to a fall of blood pressure during and after operation part of the manifestations of shock. The blame is usually and possibly unjustly put on the anesthetic. In a series of 130 operations followed by us, and in which falls of blood pressure were checked after about 20 minutes, we observed postoperative complications in only 2 of them; these were suppression of urine and a pulmonary embolism. There were 3 deaths after operation: 1 from reactionary hemorrhage after prostatectomy, 1 from sepsis after resection of the rectum, and 1 from cardiac failure after amputation for a neglected secondarily infected tuberculous knee joint. The patients were elderly and had operation risks. From our studies it is our opinion that by maintaining the blood pressure at normal levels during operations, the incidence of postoperative complications and fatalities in our series has been reduced. This opinion is borne out by the work of Papper and associates (1943) which appeared after ours was completed. They noted that a significant fall in blood pressure occurred in 70 per cent of a series of 243 patients operated on under spinal anesthesia and that complications during and after operation were greater in this group than in the remaining 30 per cent in which the blood pressure fell only slightly or not at all. In the former group the incidence of complications (not including nausea) was 28 per cent, and in the latter only 3 per cent. There were 7 cases of syncope in the group in which the blood pressure fell and none in the group in which it was maintained.

In average surgical practice blood pressures are sometimes determined at operation in the case of poor risk patients but we have observed that the behavior of a patient during operation cannot be predicted. We have seen elderly and poor risk patients survive such major operations as splenectomy or a complicated gastric resection lasting hours, with hardly any fall in blood pressure; yet young and moderately fit patients have shown a pronounced fall in blood pressure following such relatively minor procedures as ligature and injection of varicose veins, orchidectomy and repair of hernias. We do make a plea, therefore, for the routine repeated determination of blood pressure in all major operations; the request must come from surgeons convinced of its service to patient.

#### PHARMACOLOGY OF METHEDRINE

In man moderate doses of methedrine act as a pressor agent by vasoconstriction of the per-

# DODD, PRESCOTT THE USE OF METHEDRINE IN SURGERY

peral vessels, in larger doses it acts directly on the heart. In doses of 15 milligrams or more it causes an increase in the rate and depth of respiration. Administered by mouth or parenterally it acts as a cortical stimulant like amphetamine, and produces a state of euphoria and increased mental clarity. We have observed that in doses of 15 milligrams or more parenterally it is capable of abolishing the sedative effect of  $\frac{1}{6}$  grain of morphine and  $\frac{1}{150}$  grain of scopolamine. Its analeptic action as tested on mice is one and a half times that of amphetamine (Trevan, 1938). In the normal person a rise of blood pressure (e.g. from 120 mm to 180 mm systolic), palpitations, restlessness, sleeplessness, tachycardia, tremor, and dryness of the throat are observable in doses of 60 to 70 milligrams parenterally. Surgical patients with a low blood pressure have tolerated these amounts without any untoward effects. The acute toxicity as tested on the rat is  $\frac{1}{8}$  to  $\frac{1}{10}$  that of ephedrine or pholedrine. The pressor activity of methedrine on the pithed cat was rather disappointing (Trevan, 1938), nevertheless we decided to evaluate the drug under truly clinical conditions.

operative procedures were noted. In 54 cases the blood pressure dropped to 80 millimeters or less systolic or the pulse pressure to 10 millimeters or less. After 20 minutes at these low levels (actually natural recovery seldom occurred), we considered that these patients needed a pressor agent and methedrine was injected in the dosage to be mentioned—no other agents or stimulants such as carbon dioxide, saline, blood transfusion, were given. Blood pressure falls were often observed after incising the peritoneum, handling the viscera, pulling on the mesentery, exploring the bile ducts, and also in operations on the kidney, testicles, and gall bladder. We also recorded a temporary fall in blood pressure after the injection of varicose veins.

The blood pressure and pulse rate are also affected by the anesthetic used. Thus spinal anesthesia commonly results in a fall of blood pressure to 90 to 80 millimeters systolic, ether and gas if given rapidly cause an increase in pulse rate.

Surgical experience shows that low blood pressure does recover naturally, but how soon? We observed one debilitated patient (? gallstones) in whom recovery would ordinarily be expected to be slow and possibly complicated. During the laparotomy (Case 3), the blood pressure fell to 60/40 millimeters and showed no signs of recovery after 1½ hours. After this we did not feel justified in leaving her with so low a blood pressure and methedrine was given (15 mgm intramuscularly + 15 mgm intravenously). She responded immediately. In 2 minutes the blood pressure rose to 105/60 mm and in 10 minutes it was at its preoperative level, and with small fluctuations was maintained for at least 3¼ hours, when observations were discontinued. She recovered uneventfully.

ANALYSIS OF 130 OBSERVED OPERATIONS  
(Serial blood pressure and pulse recorded)

Cases	Methedrine used	Methedrine not used
Cholecystectomy and choledochostomy	11	8
Gastrectomy and gastroenterostomy	17	6
Excision of colon and rectum	4	3
Mastectomy for carcinoma (Halsted)	5	1
Laparotomy and appendectomy	16	4
Hernial repair	16	11
Cervical sympathectomy and excision of cervical rib	7	2
Operations on kidney for stone or carcinoma	7	4
Operations on testicle	7	4
Operations on ureter and bladder	4	2
Ligature and injection of varicose veins	17	4
Thyroidectomy	5	1
Splenectomy	1	—
Hemorrhoidectomy	2	1
Prostatectomy	3	—
Hysterectomy	1	1
Amputation	1	2
Miscellaneous	7	—
Totals	130	54

## ANESTHETICS USED

The anesthetics used in this study included (a) *spinal* 1,500 to 1,200 nupercaine, either alone or supplemented by gas-oxygen, gas-oxygen-ether, or by pentothal, (b) *general anesthetics* such as nitrous oxide gas and oxygen, nitrous oxide gas-oxygen-ether, open ether, and trichlorethylene, (c) *local anesthesia*, with amethocaine 1,000 either alone or supplemented by nitrous oxide gas-oxygen, ether, trichlorethylene or pentothal, (d) *pentothal* alone or with nitrous oxide gas-oxygen, ether, or trichlorethylene and oxygen. After the injection of a spinal anesthetic the blood pressure usually falls rapidly to 80 millimeters systolic, but this fall is inconsistent, and the blood pressure may not drop more than 10 to

## CONDITIONS OF USE OF METHEDRINE

Blood pressures and pulse rates were recorded at intervals of 3 to 5 minutes in 130 operations, many of them major. Details and times of the

no millimeters systolic. This fall in blood pressure is regarded by some as a type of secondary shock (Schuberth, 1938). There has been a considerable vogue for giving pressor drugs just before the spinal anesthetic to prevent the fall in blood pressure. We refrained from giving methedrine as routine preferring to wait and see if the blood pressure fell to 80 millimeters systolic or less, and if it did so to give it a chance to recover spontaneously before giving methedrine. We believe that this is important because the administration of a powerful pressor agent to a patient with a normal blood pressure may result in an abnormally high rise, which may increase hemorrhage from the operation wound, impoverishing the patient and hindering the surgeon. An abnormally high blood pressure is dangerous in a patient with myocardial disease, hypertension or arteriosclerosis.

#### ADMINISTRATION

We found methedrine effective as a pressor agent when administered subcutaneously intramuscularly and intravenously. Since absorption from the subcutaneous tissues is slow in circulatory failure the intramuscular and intravenous routes were used. As an intramuscular injection was effective within approximately 5 minutes, this was given in preference to an intravenous injection. Provided a vein could be readily entered then the most rapid restoration of a profound fall in blood pressure followed the intravenous route. An intravenous injection produces an almost instantaneous response, while an intramuscular one acting more slowly has an action that is prolonged for several hours. Whenever an intravenous injection was given a sustaining depot dose was given intramuscularly at the same time. A total of 68 injections were given to 54 patients, 51 intramuscularly and 7 intravenously of the latter 14 were given simultaneously with intramuscular injections.

#### DOSEAGE

*Single dose.* The dose for a single intramuscular injection of methedrine varied from 5 to 30 milligrams, for a single intravenous injection from 0.1 to 20 milligrams. Naturally it depended upon the patient's condition. In 44 of the 54 cases studied (i.e. 81 per cent), a single injection was sufficient to restore the blood pressure to normal limits.

*Minor operations.* If the blood pressure fell during hernia operations under spinal anesthesia, or during the ligation and injection of varicose veins, smaller intramuscular doses of methedrine

were adequate as the patients responded readily with incorrect large doses the blood pressure may easily rise to high levels. When the systolic pressure dropped to 80 millimeters or the pulse pressure to 5 to 1 millimeters a 10 milligram intramuscular injection of 15 to 20 milligrams was generally adequate. This amount was increased to 25 milligrams if the systolic pressure fell below 80 millimeters. Intravenous injection is not as a rule necessary.

*Major operations.* In major operations in which the blood pressure fell below 80 millimeters the dosage of methedrine was 15 to 30 milligrams, given either intramuscularly in a single dose or as a combined injection of 10 to 15 milligrams intravenously and 5 to 20 milligrams intramuscularly. When the blood pressure fell to 80 millimeters to 40 millimeters systolic, or below then

5 to 30 milligrams was given intramuscularly and 15 to 20 milligrams intravenously. Only 3 patients received the maximum single dose of 30 milligrams intramuscularly plus 20 milligrams intravenously. Each case was critically evaluated in the light of the patient's age, physique, blood pressure, color, temperature and respiration. Patients with a low blood pressure and in a state of impending shock need larger doses.

*Multiple injections.* 10 of our cases more than one injection was given, although on an average 30 minutes was allowed for the first dose to act. If the response was not sufficient after this time a second injection was given. Subsequent experience revealed that the first dose was too small in 4 of the 10 cases leaving 6 of 54 who really needed more than one injection. Seven patients were given 2 injections to restore the blood pressure to normal, although 1 of these the dose was too cautious, leaving 3 who really required more than one injection. In 3 patients 3 injections were given. 1 was a radical mastectomy in which small doses were deliberately given to keep the pressure at low normal levels and to minimize the risk of hemorrhage from the large wound.

Although the maximum single dose given as a combined injection of 20 milligrams intramuscularly and 20 milligrams intravenously—that is 40 milligrams in all—the maximum total dosage received by any one patient was 75 milligrams given in 3 intramuscular injections over a period of 13½ hours during a plastic operation for hydro-nephrosis. Other patients received total doses of 70, 65, 55, and 50 milligrams respectively. Untoward effects were noted. All recovered, 3 uneventfully one with moderate postoperative vomiting.

In our early administrations, mistakes in dosage were made. In the first case too many small doses of 10 milligrams were given, one large dose of 30 milligrams would have been more effective (Case 1). In another case (Case 36) a large dose (30 milligrams) was given to a patient whose blood pressure had fallen to only 90 millimeters. This was given intramuscularly, but some of it probably entered a small vessel, as the blood pressure shot up to 240 millimeters systolic in under 15 minutes. In only 3 patients did the blood pressure rise to more than 30 millimeters above the preoperative systolic pressure. This occurred in the early cases before the dosage had been learned.

#### TIME TAKEN FOR METHEDRINE TO ACT

*Intravenously* After an intravenous injection the blood pressure began to rise within a minute. The time taken for the maximum pressure to develop depended upon the dose and varied from individual to individual. The shortest time was 2 minutes and the longest 10, with an average of 5½ minutes.

*Intramuscularly* An intramuscular dose of 15 to 30 milligrams produced a measurable rise of blood pressure in from 2 to 10 minutes, with an average of 4 minutes. The peak rise after an intramuscular injection was reached in from 4 to 38 minutes, with an average of 18 minutes.

#### DURATION OF ACTION OF METHEDRINE

The duration of action of an intravenous dose of methedrine is variable, from half an hour to several hours.

A carefully calculated intramuscular dose or a combined intramuscular-intravenous dose produces an effect which lasts for many hours in most patients. In 44 of 54 cases a single intramuscular or combined intramuscular-intravenous injection permanently restored the systolic blood pressure to its preoperative level or to within 90 per cent of it. This pressure was sustained throughout the operation and for recorded periods of from half an hour to over 48 hours after operation.

Nine patients required more than one injection, in all the blood pressure was sustained throughout the operation and for several hours afterward. In only 1 case of 54 did the methedrine fail to restore and maintain the blood pressure to 100 millimeters systolic.

#### EVALUATION OF PRESSOR ACTION OF METHEDRINE

*Systolic pressure* Methedrine has been found to exert an effective gradual and sustained pressor action in surgical patients with a low blood pressure, only 1 patient failed to respond to the drug.

In 97 per cent of the cases studied the blood pressure was restored to normal levels in a period varying from 2 to 18 minutes. In a patient with a low blood pressure who has received an adequate intramuscular-intravenous injection of methedrine, a measurable rise in blood pressure occurs in 1 minute, reaches a maximum in 5 to 15 minutes, and is sustained over a period of several hours after the operation (Fig 1). There is no precipitate rise and fall, such as occurs with ephedrine (Fig 3) or pholedrine. The blood pressure curve is of a plateau type and once the blood pressure is restored it is maintained. After an intramuscular injection (Fig 2) the rise in blood pressure is more gradual, but the maximum pressure is of the same order as after an intravenous injection, and the action is usually more prolonged.

The systolic pressure after the administration of methedrine rarely rises above the preoperative level unless an overdose is given. In only 3 of our cases did it rise more than 30 millimeters above the preoperative level, in any case it quickly settles down to the normal level, or within 90 per cent of it.

The average preoperative blood pressure of our 54 patients was 137 millimeters systolic, during the operation the average figure to which it dropped was 66 millimeters systolic. This rose to an average of 133 millimeters in an average time of 18 minutes after the methedrine was given. The average figure to which it finally settled was 124 millimeters, measured after periods from 30 minutes to 48 hours after operation. This corresponds to a permanent rise to 91 per cent of the preoperative level. Repeated observations after operation showed that the blood pressure was maintained.

One injection was adequate in 44, or 81 per cent, of the patients, more than one injection was given in 17 per cent, and 1 patient, or 2 per cent, failed to respond. The blood pressure was restored to normal levels in 52 out of 54, or 97 per cent, of the cases.

*Pulse pressure* The pulse pressure was increased from an average of 14 millimeters, when the methedrine was administered, to a maximum of 55 millimeters. The final value was 40 millimeters.

*Pulse rate* The effect on the pulse rate was variable. Generally there was an increase of 15 beats to the minute, although in 6 patients there was a fall of an average of 12. In 3 cases the pulse rate was unaffected. After methedrine was given to pulseless and collapsed patients the pulse became full and bounding. Both the anesthetic and

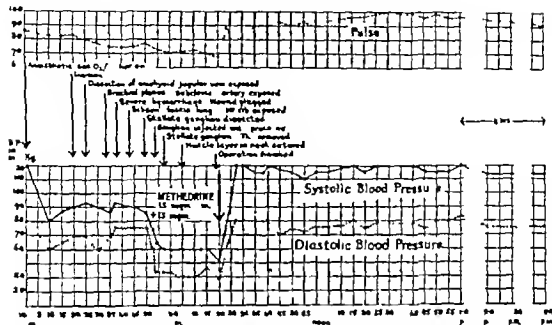


Fig. Effect of combined intravenous intramuscular injection of methedrine on blood pressure and pulse rate during cervical sympathectomy. Only one injection was necessary.

the surgical trauma affect the pulse rate so that it is often impossible to get a clear picture of the effect of the drug alone.

**Respiration.** This was not recorded routinely but it was observed that methedrine increased the rate and depth of respiration of patients who were in a poor condition and whose respiration was shallow.

**Repeated doses.** Repeated doses are effective. Our considered opinion is that the best result follows a carefully assessed and adequate dose given in one injection.

#### CONSTITUTIONAL REACTIONS

Apart from extra systoles in 3 patients nothing clinically abnormal was noted in those who had received methedrine. The effect of the anesthetic cannot be excluded as extra systoles were also observed in patients under ether who had not received methedrine.

In the unanesthetized person methedrine acts as a cortical stimulant and produces sensation of euphoria like amphetamine (Golla et al., 1940). This effect was not noticed in our patients, presumably being annulled by the premedication, anesthetic, and postoperative morphine which was given every 4 hours after major operations. Three of 34 patients became excited or delirious after operation: 2 were elderly patients who had

had hernia operations and their behavior was not unexpected.

When one of the authors (F. P.) received 70 milligrams of methedrine intramuscularly in divided doses over 5 hours the blood pressure rose from 130 millimeters systolic to 180 millimeters, and vomiting, cortical stimulation, persistent tachycardia, and severe palpitations were experienced. The acute symptoms lasted 24 hours and the tachycardia and palpitations for several days. We suggest, therefore, caution in giving total doses of more than 50-60 milligrams although this dose appears to be tolerated well by patients with a low blood pressure. Premor agents are potent drugs; they should never be given without reading the blood pressure before each injection. Overdose may be disastrous in a patient with myocardial and coronary disease, hypertension, arteriosclerosis, or hyperthyroidism. The possibility of a cerebral accident in an elderly patient with hypertension or arteriosclerosis must be borne in mind. One of us (H. D.) has experienced them on three occasions outside this study.

#### ELECTROCARDIOGRAPHY

Electrocardiograms were taken in 3 patients 2 of whom received the maximum single dose of 40 milligrams of methedrine. No significant changes were observed. In 1 case there was tachycardia.

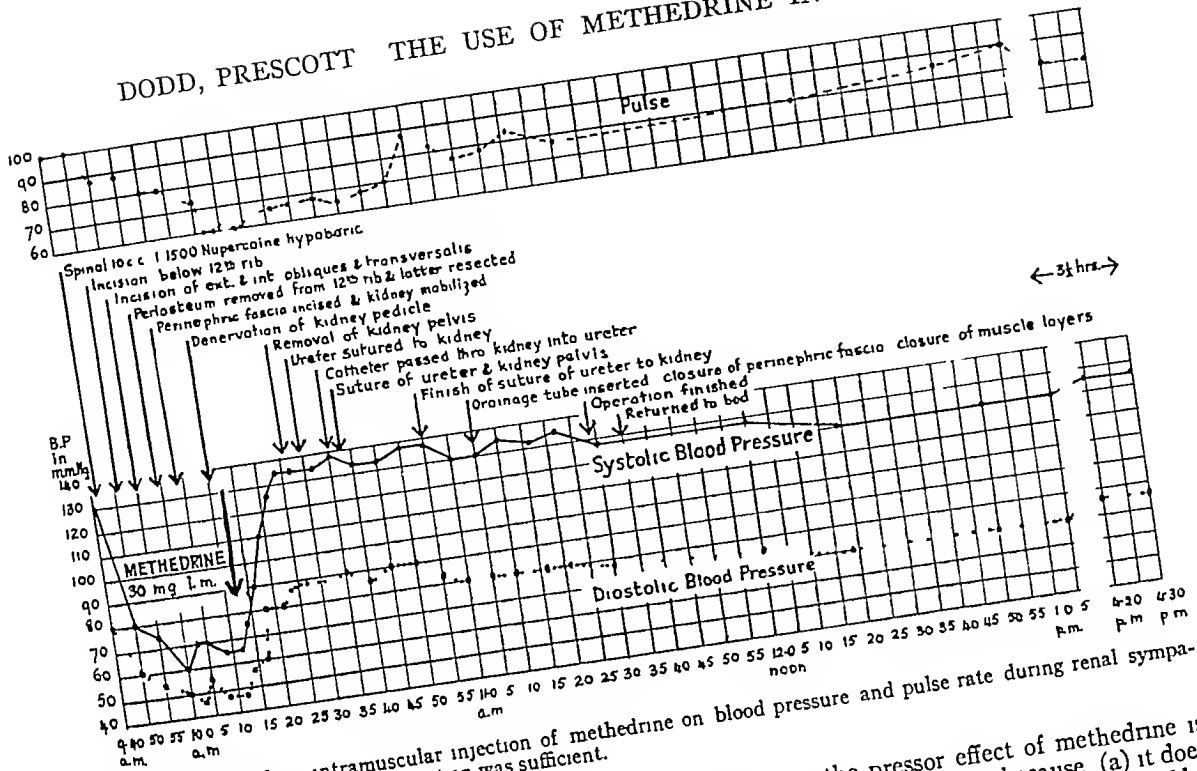


Fig 2 Effect of an intramuscular injection of methedrine on blood pressure and pulse rate during renal sympathectomy and pyelectomy One injection was sufficient.

porary shortening of the RST segment in lead 2, isoelectric T and P waves in lead 1, and upward displacement of the ST segment in leads 2 and 3. These changes were transient and we attach no significance to them. The clinical significance of some abnormal electrocardiographic findings is not certain enough to deny patients the benefit of this drug. Moreover anesthetic and surgical trauma may produce temporary changes in the electrocardiogram and their effect cannot be excluded when testing a drug at operation (Kurtz et al, 1936, Brechling and Hansen, 1939). The electrocardiogram of one of the authors (F P) taken 24 hours after the intramuscular injection of 70 milligrams of methedrine was normal.

Many drugs used in emergencies, such as adrenalin, digitalis, atropine, and ergometrine may produce temporary changes in the electrocardiogram (Graybiel and White, 1941, Hartwell et al, 1942).

## COMPARISON WITH OTHER PRESSOR AGENTS

One of us (Dodd, 1939, 1940, 1942) has had the opportunity of comparing clinically the pressor effects of methedrine with those of adrenalin, ephedrine, and pholedrine (veritol). Their relative clinical value as pressor agents can be seen by comparing Figures 1 and 2 with Figure 3. We

consider that the pressor effect of methedrine is superior to that of these drugs because (a) it does not produce a precipitate rise, nor is it followed by sharp falls of blood pressure, (b) the blood pressure is gradually restored to and maintained at its preoperative level or within 90 per cent of it for several hours, the duration of effect of adrenalin, ephedrine, and pholedrine is not more than 30 to 45 minutes, (c) one injection is usually sufficient.

We have not had the opportunity of testing s-methylisothiouraea, neosynephrin, paredrine and phedracin, but a survey of the literature reveals that they have drawbacks. Thus s-methylisothiouraea, recently reported on by Smirk and McGeorge (1942), can only be given slowly by the intravenous route, and the single clinical report on it relates only to its use in spinal anesthesia, moreover there is no account of what happened after the operations. The duration of action of a single dose of neosynephrin is only  $\frac{1}{2}$  to  $\frac{3}{4}$  hour and several injections (from 2 to 6, and in 1 case 23) are often necessary to raise and maintain the blood pressure (Johnson, 1937, Lorhan and Oliverio, 1938, Bittrich, 1939, Brunner and de Takats, 1939, Silvers and Leonard, 1940, Lorhan and Lalich, 1940). Thus in a series of cases reported by Bittrich (1939) 63 per cent of the patients treated with neosynephrin required from

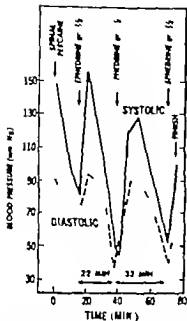


Fig. 3. Effect of intravenous injections of ephedrine on blood pressure during radical excision of breast carcinoma. (From *Lancet*, 949, Feb. 24, p. 159.)

2 to 6 injections to maintain the blood pressure during operations under spinal anesthesia. Neosynephrin may cause partial heart block as a result of excessive slowing of the pulse, for example to 30 beats per minute (Branner and de Takats, 1939).

Paredrine may produce an excessive rise in blood pressure (Loman et al., 1939; Altchule and Gilman, 1939) and persistent coupling of heart beats, systolic murmurs and splitting of heart sounds (Abbott and Henry, 1937). Its duration of action appears to be longer than that of the pressor drugs previously mentioned, but not as long as that of methedrine.

Phedracine like neosynephrin slows the pulse and must be given intravenously to obtain the maximum effect. It also apparently produces unpleasant side effects, e.g. desire to micturate, feeling of coldness down neck and spine and sensation of tightness across the head (Jones and Wilson, 1935). In the doses given by Jones and Wilson (1935) phedracine sometimes produced an excessive rise in blood pressure.

We have not had the opportunity of using methedrine in cases of traumatic shock, but we think that its sustained effect makes it worthy of trial in such cases.

#### CASE RECORDS

The following case histories illustrate the values of methedrine as a pressor agent in operations.

**CASE 2.** M. M., female, aged 45 years, had laparotomy and operation lasted 4 hours. Her condition, as poor, she as then evacuated. Her preoperative blood pressure was 120/80 millimeters. The anesthesia, as local with anesthetic, followed by nitrous oxide gas-oxygen-ether. After exploration of the abdominal organs, the blood pressure fell to 80/55 millimeters, and after appendectomy and suture of the ilio-psoas muscle to 55/35 millimeters. It remained between 50/40 millimeters and 60/35 millimeters for 34 hours. There were no signs of natural recovery. Methedrine 5 milligrams, as given 10 minutes previously plus 5 milligrams intramuscularly. In minutes the blood pressure rose to 100/60 in minutes to 110/60 millimeters and as maintained between 100 and 120/60 millimeters for at least 3 hours. The pulse rate rose from 70 to maximum of 100. Recovery as uneventful.

**CASE 7.** A. L., male, aged 50 years, had partial gastrectomy and cholecystectomy. The anesthesia, as spinal with imperial. Duration 4 hours. The preoperative blood pressure was 120/80 millimeters. Ten minutes after the spinal anesthesia the blood pressure fell to 80/60 millimeters and during the next half hour fell progressively to 40/30 millimeters. Methedrine, 5 milligrams, as given intramuscularly and 5 milligrams intravenously. 15 minutes the pressure was 100/60 millimeters in 5 minutes 120/80 millimeters, then fell during the next 3 hours to 80/60 millimeters and was at this level until the end of the operation. Pulse rate as raised from 80 to 95 per minute. Recovery as uneventful.

**CASE 1.** J. E., male, aged 63 years, had Radical repair of right inguinal hernia. Operation lasted 4 hours. Anesthesia as produced by local infiltration with procaine. The preoperative blood pressure was 120/80 millimeters. After 3 minutes the blood pressure was 80/55 millimeters. A second direct cut as discovered and after difficulty the bladder as freed from it. Ten minutes later the blood pressure dropped to 50/40 millimeters. Methedrine, 5 milligrams, as administered intramuscularly and 5 milligrams intramuscularly. 15 minutes the pressure rose to 110/70 millimeters and the next 5 minutes climbed to 120/70 millimeters and finally to 130/80 millimeters. It settled to 120/70 millimeters by the end of the operation and as at this level 4 hours later. Pulse rate rose from 45 to 54 per minute. Patient recovered.

**CASE 5.** W. S., female, aged 47 years. A cholecystectomy and drainage of common bile duct required 34 hours. The preoperative blood pressure was 110/75 millimeters. Anesthesia as spinal (100 imperial). While the rectus muscle as being separated the blood pressure fell to 50/35 millimeters and for following 15 minutes was too low to record. Methedrine 30 milligrams, as given intramuscularly. There was rise to 90 millimeters systolic in minutes and to 100/60 millimeters in 5 minutes, which as maintained for 1 hour. Further 5 milligrams methedrine as injected intramuscularly and the blood pressure slowly rose to 120/80 millimeters and was sustained there for 4 hours. The pulse rate was raised temporarily from 60 to 100. The effect of methedrine lasted at least 5 1/2 hours. Patient recovered.

**CASE 4.** D. A., female, aged 33 years, had cervical sympathectomy for paralytic agitator. Operation lasted 4 hours. The anesthesia as nitrous oxide gas-oxygen-ether. The preoperative blood pressure was 120/80 millimeters. Ten minutes after the incision, blood pressure fell to 80/55 millimeters. Thirty minutes later the systolic pressure





TABLE I.—SUMMARY OF CASES SHOWING EFFECT OF METHEDRINE ON BLOOD PRESSURE AND PULSE RATE—Continued

No. Sex, Age	Operation	Anesthetic	Dose in mg.	Blood pressure in mm.				Effect on pulse per min.	Time taken for methedrine to act— min.	Time to pro- duce maxi- mum drop in blood pres- sure— min.	Reaction of system and blood pressure after this time
				Pre- opera- tive blood pressure	Blood pressure just before giving methedrine	Maxi- mum blood pressure after methedrine	Final blood pressure				
24 F, 47	Cholecystectomy	Spinal surgical + local procaine	30 Lm + 15 Lm	95		5/ 80	20/ 80	+24		15	At least 1 hr 20-30 min.
25 F, 45	Cholecystectomy	Spinal anesthesia	30 Lm	90/ 70	65/	20/ 80	20/ 75	+30			At least 1 hr 20-75 min.
27 F	Cholecystectomy	Spinal surgical + propofol	+ + + Lm	120/100	90/ 40	105/ 65	100/ 70	+15		30	1 hr 200/70 mm
28 F, 45	Cholecystectomy	Spinal anesthesia	30 Lm	170/120	100/ 8	170/100	170/100	+10			At least 1 hr 30 min 170-100 mm
29 M, 49	Amputation	Local procaine + propofol	Lm	20/ 70	20/ 40	120/ 70	100/ 70	+10			At least 1 hr 250/70 mm
30 F, 33	Cervical sym- psectomy	Gas-oxy pro- pofol	30 Lm	20/ 70	20/	30/ 80	20/ 65	+5			At least 1 1/2 hr 20-65 mm.
31 F, 33	Cervical sym- psectomy	Gas-oxy pro- pofol	Lm	20/ 70	20/ 40	20/ 80	5/ 8	+20			At least 1 1/2 hr 75 mm
32 M, 60	Ectopic section	Spinal anesthesia	30 mL	20/ 80	90/ 75	20/ 80	5/ 75	+10		1	At least 30 min 80 mm
33 M, 20	Fluorohol	Spinal anesthesia	30 mL	100/ 95	20/ 40	20/ 80	120/ 80	-	10	15	At least 1 hr 120/80 mm
34 F, 29	Pituitary tumor	Spinal anesthesia	30 mL	20/ 80	20/	100/ 80	100/ 80	+10	1	25	At least 1 1/2 hr 100/80 mm
35 F, 33	Thyroidectomy	Local procaine	10 mL	20/ 80	90/ 80	6/ 80	120/ 80				Total and of surgery 10-15 min
36 F, 45	Ovaryectomy	Spinal anesthesia	30 mL	70/ 90	90/ 80	120 30	20/ 90	+20			At least 1 hr 30 min 20-90 mm
37 F	Laparotomy	Spinal anesthesia	30 mL	20/ 70		20/ 90	120/ 70	+15			At least 1 hr 40 min 20-70 mm
38 F, 34	Laparotomy	Spinal anesthesia + propofol	25 mL	20/ 65	20/ 40	20/ 70	20/ 70	-		15	At least 20 min 20-70 mm
39 M, 30	Ovary	Spinal anesthesia	25 mL	170 70	20/ 45	170/ 75	20/	+		20	At least 1 1/2 hr 20/75 mm
40 M, 55	Bladder	Local + propofol	30 mL	120/ 70	100/ 80	20/ 70	20/ 70	+		10	At least 1 hr 40 min 20-70 mm.
F, 35	Vasectomy	Propofol + oxy ether	150 mL	20/ 65		20/	5/ 80	-	10	15	At least 1 hr 70 mm
41 F, 55	Kidney	Spinal anesthesia	30 + 10 mL	80	5/ 30	5/ 60	15 30	Not measured			At least 1 hr 5/30 mm
42 F, 33	Kidney	Spinal anesthesia + propofol	30 + 30 + 1 mL	5/ 80	65/ 80	90/ 65	90/ 70	+	10		B.P. not raised above 90/70 mm. after 1 1/2.
43 F, 38	Kidney	Spinal anesthesia	30 mL	20/ 80	15/	20 30	20/ 80	+20			At least 1 hr 20/70 mm
44 F, 44	Kidney	Spinal anesthesia	30 mL	20/ 80	65/	15 75	20/ 80				At least 1 hr 20-80 mm
45 M, 13	Arterio venous	Gas-oxy pro- pofol	20 mL	120 100	95	90 100	20 120	+			At least 1 hr 20-100 mm
47 F, 30	Vascular valve	Spinal anesthesia + propofol	20 +	20/ 80	20	45 30	25 70	+20			At least 1 hr 70 mm.
M, 40	Periton	Spinal + propofol	25 mL	15/ 80	20 65	20 80	20	+15			At least 1 1/2 hr 25/80 mm



It initially rose to 13 7/35 millimeters, then in minutes fell to 10/75 millimeters and was maintained between 9/70 and 10/70 millimeters for the rest of the operation. Three hours later the pressure was 9/70 millimeters. Pulse rate fell after methedrine from 60 to 54 per minute. Patient recovered.

#### SUMMARY

Of 130 observed operations, 54 patients were found suffering from an unduly low systolic or pulse pressure and some degree of impending surgical shock. The capacity of methedrine to meet the needs of these patients has been studied under average operating conditions of four general hospitals. The drug was never given for the sake of measuring its effect on a patient but only when the surgeon, anesthetist and observer agreed that the patient was in need of it. Anesthetics included all those in common use.

Under these conditions methedrine has been proved to be an effective pressor agent with a gradual prolonged action, and with no undesirable side effects in the dosage stated.

The effective dose is from 15 to 30 milligrams intramuscularly or 5 to 20 milligrams intravenously plus a depot dose of 10 to 20 milligrams intramuscularly.

In 97 per cent of the cases the systolic pressure was restored to normal levels in from 2 to 18 minutes. The systolic pressure was raised from an average of 67 millimeters to an average maximum of 135 millimeters and settled to an average minimum of 124 millimeters. This last figure corresponds to 91 per cent of the average preoperative value (137 mm). There is no abnormally high rise if the patient's circumstances are evaluated and the dose is selected accordingly. One injection was adequate in 8 per cent of patients; repeated injections were given in 17 per

cent in 1 case; in 2 per cent, there was no response.

The pressor effect is maintained for several hours after operation.

Clinically methedrine is considered to be superior to adrenalin, ephedrine and pholedrine as a pressor agent.

#### REFERENCES

1. ARNOTT, W. O. and HERR, C. M. *Am. J. M. Sc.* 957, 93, 661.
2. ALLEN, W. D. and GILM, S. A. *England J. M.* 930, 600.
3. BITTNER, V. M. *Asaiah & Asaiah* 930, 8, 20.
4. B. LORAIN, S. and H. VICK, T. *Med. Med.* 930, 3, 220.
5. BRETHER, R. S. and DE TAY, R. G. *Surg. G.* *Obst.* 930, 63.
6. DODD, H. *Lancet*, 940, 352.
7. Ibid., 942, 408.
8. DODD, H. and MERRITT, G. *Brit. J. Surg.* 930, 27, 32.
9. GILL, F. L. et al. *J. Med. Sci.* 940, 86, 42.
10. G. VITEL, L. and WATTS, P. D. *Electrocardiography in Practice*. London: Saunders, 94.
11. HARTWELL, A. B. et al. *J. Clin. Invest.* 942, 409.
12. HARR, A. L. *Recent Advances in Anesthesiology*. London: Blackiston Churchill, 942, p. 5.
13. JONES, C. A. *Surg. Gyn. Obst.* 937, 64, 452.
14. JONES, J. A. and R. LLOYD, C. *Lancet*, 938, 65.
15. KOSMA, H. *Arch. Surg.* 942, 45, 606.
16. KRAZ, C. M. B. *Brit. J. H. and Gynaecol.* H. H. *J. Am. M. Ass.* 945, 66, 444.
17. LORAIN, J. et al. *Am. Heart J.* 930, 8, 20.
18. LORAIN, P. H. and LLOYD, J. L. *Anesth. & Asaiah* 940, 9, 66.
19. LORAIN, P. H. and LLOYD, R. M. *Anesth. & Asaiah* 935, 7, 44.
20. M. LLOYD, J. *Brit. M. J.* 94, 326.
21. PUPPER, E. M. et al. *J. Am. M. Ass.* 945, 27.
22. SCHWARTZ, O. O. *Acta chirurg. scand.* 935, 78, 1.
23. SILVER, H. L. and LORAIN, I. C. *Am. J. Surg.* 940, 79.
24. SMITH, F. H. and McGOVERN, M. *Lancet*, 942, 309.

# RELIEF OF ESSENTIAL DYSMENORRHEA WITH ETHINYL ESTRADIOL

ROBERT A LYON, M D, San Francisco, California

ESSENTIAL dysmenorrhea was observed by Wilson and Kurzrok to occur only in ovulatory cycles. Confirmation was offered by Sturgis and Albright (6) who in the same report described the mechanism of estrogenic relief of dysmenorrhea under prescribed conditions. Sturgis (5) later utilized the orally active nonhormonal estrogen, stilbestrol, in treating single dysmenorrheic menstrual episodes. Subsequently, estradiol dipropionate was employed in the treatment of essential dysmenorrhea by Sturgis and Meigs (7) in a further development of the basic thesis. Sturgis (5) defines essential dysmenorrhea as menstrual cramps associated with the presence of a secretory endometrium. It is the purpose of this presentation to examine the effect on essential dysmenorrhea which may be obtained by means of an orally effective estrogen, ethinyl estradiol. This preparation was synthesized by Hohlweg and Innhoffen and is exceptionally potent, very small quantities being effective. It appears to be removed at a slow rate by the liver (1). Experience of different observers (1, 8) agrees in that it does not show significant toxic manifestations. Those who cannot tolerate the substance appear to be very infrequently found.

Sturgis' development of the use of estrogens in controlling the symptoms of dysmenorrhea had as a basis the inhibition of ovulation. When an adequate dose of estrogen was given early enough in the cycle to prevent the follicle-stimulating hormone production in the hypophysis and was continued sufficiently long, it was effective in relieving the expected menstrual period from pain. This appears to be an all-or-none effect. To obtain this, maturation and rupture of the follicle must be prevented by estrogen treatment for about 21 days prior to the next expected menses.

Essential dysmenorrhea involves the ovulation mechanism since it occurs only in association with a functioning corpus luteum (3). Observations of basal temperatures showed a progestational biphasic rise in the second half of the cycle in pa-

tients who had dysmenorrhea. When ovulation is suppressed no dysmenorrhea followed (5, 6, 7). Estrogen in an effective dose, when given by the 5th cycle day and maintained for at least 3 weeks, prevented the recurrent crampy-like pains characteristic of dysmenorrhea of the essential type (7).

*Experimental* Twelve patients were followed from 6 to 15 months, ovulation being determined by means of basal body temperatures, occasionally supplemented with vaginal smears and endometrial biopsies. The ages ranged from 19 to 35 years. None of the patients presented any additional gynecological disorder either by history or on physical examination. This study comprises 138 dysmenorrheic cycles evaluated by the basal body temperature method. Forty-four of these cycles have been influenced by ethinyl estradiol. This alteration has been obtained by giving 0.05 milligram of the preparation once daily by oral administration beginning at least 21 days prior to the subsequent menstrual period. This was continued for 24 days. A total dose of 1.2 milligrams sufficed for the entire cycle. In some cases, at the onset of the ensuing menstruation, the 24 day course was repeated. The third cycle was untreated and was usually accompanied by dysmenorrhea. Due to the hypothetical possibility of developing hyperplasia of the endometrium, the plan of therapy has included 1 month in 3 free from estrogen. This appears to preclude the contingency of persistent estrinism.

Following the estrogen inhibited cycles, subsequent cycle lengths ordinarily showed some change. When an estrogen was given, the cycle tended to be prolonged. The aftercoming untreated cycle is compensatorily shorter than the mean cycle length. During an estrogen influenced cycle the duration of flow ordinarily persisted about 2 days longer than the mean.

*Observations* No spontaneous anovulatory cycles were observed among the dysmenorrheic group in this report. It appears that spontaneous anovulation in a patient with dysmenorrhea is a very rare occurrence. Chance anovulatory cycles in those treated with ethinyl estradiol is too small to be significant (Table I).

The catamenia appeared 6 days on the average, after the last dose of ethinyl estradiol. In 6 of the

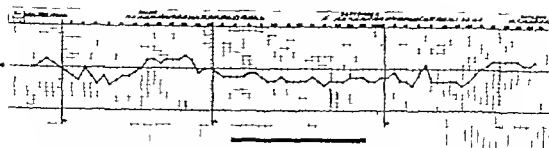


Fig. 1. The temperature curve of an estrogen treated (ovulation inhibited) cycle compared to an untreated cycle. The latter one accompanied by dysmenorrhea. The suppressed cycle free from cramp-like pain and revealed no preovulatory temperature increase. *c*, indicates menstruation; *d*, indicates dysmenorrhea.

44 instances there was no bleeding and 1 of 3 courses was followed. Either the patient was given an additional 24 ethinyl estradiol tablets after a free interval of 1 week, or nothing was given and the patient was allowed to have a normal menstrual period without treatment. In the latter event dysmenorrhea invariably occurred. Each of the patients has been treated repeatedly. In no instance did dysmenorrheic pain occur. Consecutive cycle inhibition of ovulation with ethinyl estradiol has been followed over a period of 2 cycles whereupon the patient was allowed to ovulate. The ensuing menstruation was accompanied by dysmenorrhea (Table II).

Estrogen altered the normal cycle by inhibiting ovulation, when given sufficiently early and continued for at least 21 days. This prevents ovulation and the attendant preovulatory phase of the cycle. As a result the duration of bleeding tended to be somewhat longer in this series (8 days greater in duration). The flow is described as less profuse but more prolonged. Furthermore, the length of the cycle was prolonged from a mean of 28 days to 36.7 days. As a consequence the succeeding cycles particularly when untreated were usually shortened to 5 or 6 days. Menstruation in these shortened aftercoming cycles tended to be more nearly normal in duration and quantity. Furthermore, it was accompanied by cramps.

#### ANALYSIS OF STUDY

Ethinyl estradiol as a modified hormone was effective when administered orally. There were no instances of nausea in this series and it was tolerated and liked by the patients. There were

essentially no toxic sequelae in these patients or in the reports of others (1-8). Moreover the effective dose of the estrogen was exceedingly small for these patients, being only 0.05 milligrams daily.

Although the therapy is simple and the results direct, miscalculation in the timing of dosages or omission of part of the course might occur. Such conditions predispose to failure by permitting the impending ovulation to occur. Basal temperature curves, when properly taken, reflect the inhibition of ovulation by a persistently low temperature level (3, 4). Although the day to day temperature curve variation is often marked, the trend of the anovulatory cycle curves are uniphasic. Furthermore the relief is not permanent but requires repetition monthly. Sturgis, who has had approximately 3 years experience with intermittent estrogen treatment of essential dysmenorrhea concludes, this type of therapy has little to offer as a permanent cure (7). As temporary expedient, it is satisfactory in the management of patients with severe essential dysmenorrhea who can be assured of relief in some of her cycles. In order to inhibit ovulation an estrogen must be present in effective concentration continuously from very early in the cycle. This plan amounts to starting estrogenation at least 3 weeks prior to the ensuing menses. This means the onset of estrogen administration on the average cycle occurred about the 4th or 5th day.

TABLE I.—SUMMARY OF CYCLE DATA

	number	Estrogen treated	Estrogen treated and menstruated
Cycles studied	38	44	0
Patients			

TABLE II.—EFFECT OF ESTROGEN ON THE CYCLE

	Mean days	number of cycles
Control cycle length	8	84
Estrogen treated cycle length	8	44
Duration of bleeding in estrogen treated cycles	5	44
Length of subsequent cycles	5	37
Interval from estrogen therapy to bleeding	6	44

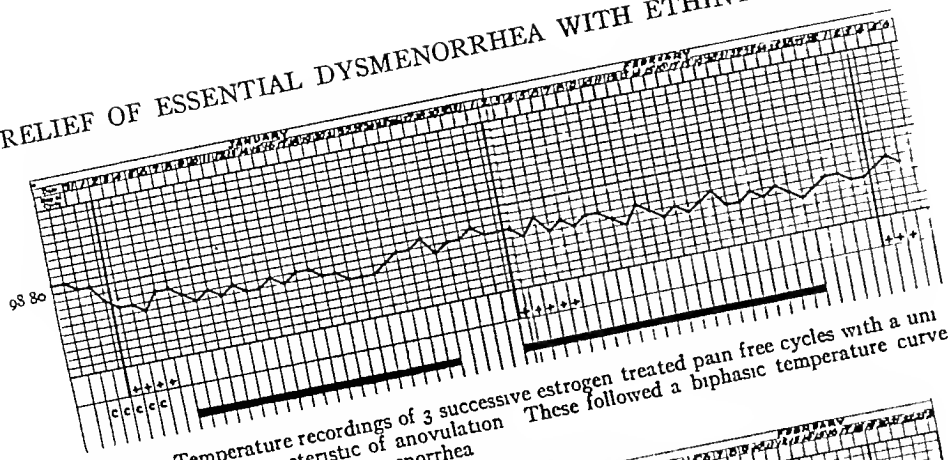


Fig 2 Temperature recordings of 3 successive estrogen treated pain free cycles with a uniphasic response characteristic of anovulation. These followed a biphasic temperature curve which was accompanied by dysmenorrhea.

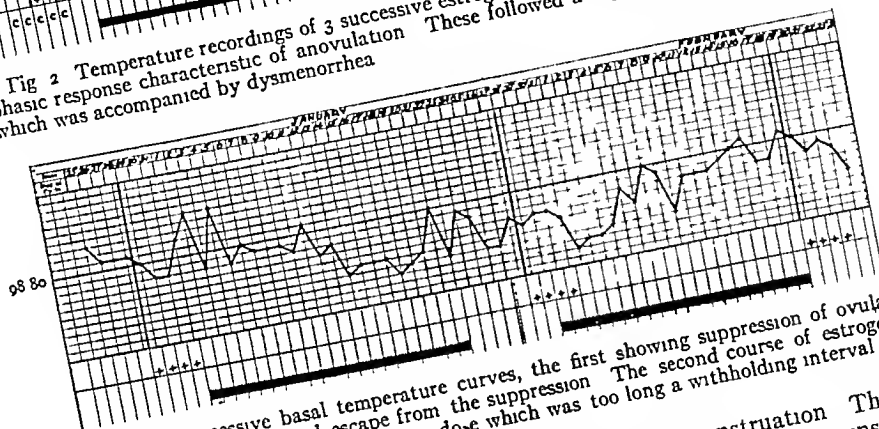


Fig 3 Successive basal temperature curves, the first showing suppression of ovulation type and the second escape from the suppression. The second course of estrogen started 8 days after the last previous dose which was too long a withholding interval.

There was no menstruation in 13 per cent of the estrogen treated cycles. This suggests that both ovulation and the catamenia were absent during these particular estrogen-treated cycles. Ordinarily the estrogen is stopped after 21 to 24 days of continuous daily administration. There followed a withholding interval of from 4 to 7 days in order to allow withdrawal bleeding to occur. The bleeding resembled menstruation except as has been described. Should the withholding time be prolonged, it is likely that ovulation will no longer be suppressed. Thereupon a pituitary gonadotropin tide apparently precedes ovulation with its consequent progestation, the dissolution of which is attended by dysmenorrheic effects. From this it appears that for ovulation suppression in two or more consecutive cycles, it is requisite that the interval allowed for withdrawal bleeding be short, namely, 4 to 7 days.

Among failures of relief of dysmenorrhea by suppression of ovulation are a start late in the cycle or insufficiency of estrogen dosage. Furthermore, it is probable that there are further stimuli to cramp-like pain. For example, it is known that instrumentation of the cervix at any time of the cycle in patients susceptible to dysmenorrhea will result in the typical cramps ordinarily found only

at the time of menstruation. These occasionally persist for many days after instrumentation or following the cessation of menstruation. Such untimely uterine pain is not ordinarily classed as essential dysmenorrhea. It is conceivable that clots, or excessive exercise might stimulate some of the symptoms resembling dysmenorrhea in an anovulatory cycle in women particularly susceptible to uterine stimuli.

Prolonged pituitary inhibition of ovulation is found naturally in instances of lactation, pregnancy, arrhenoblastoma, and granulosa cell tumor. On termination of any of these conditions, if the patient is in the reproductive age group, normal ovulatory cycles are regularly resumed. This has also been so following the administration of subcutaneous estrogen (6). Anovulatory bleeding, one of the recognized types of menstruation, then can occur with reasonable regularity, but precise 28 day cycles are not to be anticipated. None of the patients followed by Sturgis (7) for nearly 5 years nor those in our hands failed to ovulate when the estrin was withheld. Not only has ovulation invariably recurred under such circumstances, but dysmenorrhea regularly accompanied the subsequent menstruation. A similar suppression of ovulation is found, of course,

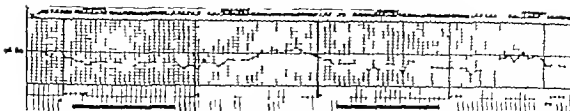


FIG. 4. Four successive cycles, the first and third being estrogen treated, thus exhibiting anovulation. The second and fourth cycles are short biphasic affairs revealing the preovulatory temperature elevation. The latter are attended by crampy dysmenorrhea, the former none at all.

during lactation. In some respects the inhibition of lactation during pregnancy may be considered to resemble that induced by this treatment. It seems permissible in the event of intractable dysmenorrhea of disabling extent to justify the temporary suppression of ovulation. As previously observed (7) for differential diagnosis between essential dysmenorrhea and recurrent abdominal pain from other causes, assistance is offered by a therapeutic trial with an estrogen as an ovulation suppression agent.

Until there has been considerably more experience, estrogenic suppression of ovulation as means of routine relief of dysmenorrhea would not appear indicated. The merit of this technique appears to be in its contribution to understanding the dysmenorrhea mechanism and in its aid in management of instances of intractable dysmenorrhea temporarily. Prolonged ovarian rest or follicle-stimulating hormone suppression has not been shown to be desirable.

The psychogenic component and the frequency of immature development of the personality in instances of dysmenorrhea are well recognized in workers in this field. Most of these patients seem to need confidence, and in this respect the method offers a step toward a sound relationship between the patient and her physician in the establishment of satisfactory adjustment.

#### SUMMARY

One hundred and thirty-eight dysmenorrheic cycles have been followed by the basal body temperature method. Of these 44 cycles have been treated for 21 to 24 days by the oral administration of 0.05 milligrams of ethinyl estradiol starting early in the cycle. This has been associated with inhibition of ovulation as determined by the basal body temperature and by freedom from dysmenorrheic cramps. Successful cycles have been treated in this manner with resultant relief from dysmenorrhea. The point at which it is being currently employed, involves permitting cycle without treatment following each 14 successive cycles in which the dysmenorrhea has been relieved.

#### REFERENCES

1. GORTEL, M. J. and BARNES, G. R. *Clin. Endocrinol.* 042, 703.
2. HOBBS, W. and LINDSAY, H. H. *Endr. Wkly.* 030, 8-17.
3. LYON, R. A. *Surg. Gyn. Obst.* 043, 76-79.
4. PALMER, A. *Surg. Gyn. Obst.* 042, 75-78.
5. STROM, S. H. *England J. Med.* 042, 26-37.
6. STROM, S. H. and MARSHALL, F. *Endocrinology* 040, 26-28.
7. STROM, S. H. and MILES, J. V. *Surg. Gyn. Obst.* 04, 73-87.
8. WATSON, B. J. *J. Clin. Endocrinol.* 042, 447.
9. WELSH, L. and KERRICK, R. *Fecundology* 04, 70.

# PERFORATION OF THE GALL BLADDER

## A Study of Twenty-Five Consecutive Cases

LEONARD L. COWLEY, M.D., and HENRY N. HARKINS, M.D., Ph.D., F.A.C.S.,  
Detroit, Michigan

THE subject of perforation of the gall bladder is of great practical importance. On its frequency and dangers depends much of the decision as to when to operate in acute cholecystitis. If the incidence and mortality of this complication are high, the argument for early operation in acute cholecystitis is strengthened, while if perforations of the gall bladder are rare and seldom fatal, delay in the surgical treatment of acute cholecystitis would not be so dangerous. In an attempt to throw light upon this subject, the present series of 25 cases of perforated gall bladder seen at the Henry Ford Hospital between 1921 and 1943 is reviewed and correlated with other reports in the literature.

### FREQUENCY

Our series of 25 perforated gall bladders represents all those available in the records of the Henry Ford Hospital. Twenty-four of these were found at operation and one was found at necropsy. During this period there were 366,459 admissions to the hospital and clinic. The exact number of these patients admitted to the hospital is not available. During the years 1921 to April, 1943, when there were 2,750 gall-bladder operations, there were 25 instances of perforated gall bladder, an incidence of 0.9 per cent. A much truer idea of the incidence is shown by the fact that during the years 1925 to 1943 when there were approximately 490 operations for acute cholecystitis, there were 23 instances of perforated gall bladder, an incidence of 4.7 per cent. In reviewing the recent literature we were struck by the wide range of figures given as to the incidence of perforation of the gall bladder, these varying from 1 to over 20 per cent. This is easily explained, however, because the lower figure is usually given for the incidence of *all* biliary disease, whereas in the higher figures the authors are talking only of the incidence in *acute* cholecystitis. It seems logical that

when one ceases thinking of perforated gall bladder as a rare disease—only 1 per cent of biliary tract affections—and concentrates on the view that perforations occur in about 13 per cent of the cases of acute cholecystitis, this complication will be discovered earlier and the mortality rate lowered by earlier operation. The incidence of the condition as shown in several articles in the literature is shown in Table I. It is seen that in 12,915 operations on the gall bladder, perforation of that organ was found, on an average, in 2.8 per cent of the cases. Our own statistic of 0.9 per cent represents the lowest figure whereas Mentzer (1936), of San Francisco, reported the highest percentage incidence of 12.1. In a collected series of 2,261 cases of acute cholecystitis, perforated gall bladder occurred, on an average, in 13 per cent, not shown in the table, is low, while Mentzer's figure of 23.5 per cent is the highest. In a total of 433 perforated gall bladders the average mortality was 20.8 per cent.

Perforation of the gall bladder is usually a consequence of acute cholecystitis with gangrene but occasionally results from other special conditions such as typhoid. Tongs (1931) reported a case of perforation of the gall bladder in typhoid. Stone (1937) reported a case of perforated gall bladder occurring in the late stage of pregnancy in which operation resulted in recovery. One of the early classical articles on the subject of perforation of the gall bladder is by McWilliams (1912). This author collected 108 cases of this syndrome with perforation into the free peritoneal cavity. His interest in the subject was aroused by having two such cases of his own and he reviewed the Presbyterian Hospital (N.Y.) series of 365 gall-bladder operations done in the preceding 15 years with 6 free perforations (1.6 per cent). In only 2 of the 6 cases was the result fatal. Blacklock (1924) found 21 perforations of the gall bladder in a series of 735 gall-bladder operations performed at the Johns Hopkins Hospital, an incidence of 2.9 per cent. Heuer (1934) collected data concerning 502 perforations of the gall bladder reported in the literature. Telford (1926) reported a series of 28 cases of

From the Division of General Surgery, Henry Ford Hospital, Detroit.

Dr. Cowley is now on active duty with the Army of the United States in Africa and was unable to participate in the final stage of writing this paper. He should not be held responsible for any errors nor for all of the ideas expressed therein.



TABLE L.—INCIDENCE OF PERFORATED GALL BLADDERS IN THE LITERATURE

Author	Total gall-bladder cases reviewed	Number of cases with acute cholecystitis	Number of perforated cases	% of total cases perforated	% of acute cases perforated	Mortality of perforated cases
Blanch, 1914	72	—	—	—	—	—
Fildes, 1921	1066	—	15	—	—	41
Mitchell, 1923	170	—	26	—	—	—
Moore, 1924	500	304	—	5	21	24
Ekman and McLoughlin, 1924	490	—	—	—	—	—
Ford, 1925	450	—	—	—	—	26
D'Aless, 1925	116	—	—	—	—	26
Moscow, 1926	140	23	13	—	57	27.7
Judd, 1927	626	—	26	—	—	17
Holt, 1929	—	37	60	—	—	26
Stone and Douglass, 1929	775	10	—	—	30	15
Glass, 1930†	—	30	18	—	—	—
Allen and Allen, 1930	—	—	—	—	7	17.8
McCluskey and Lehman, 1930	—	—	—	—	—	26
Edwards, Goring, and Goring, 1931	—	264	—	—	10	26.5
Wallace and Allen, 1931	27	5	62	—	—	—
Glass and Moore, 1931	—	130	1	—	—	—
McLachlan, Trent, and Henry, 1931	—	20	—	—	10	5
Covley and Barkin, 1931	27.3	—	—	—	—	24
Total or average	1,617	426	11	—	—	20

\*Five of the 13 total perforations occurred in cases of acute and subacute necrotic cholecystitis of chronic cholelithiasis. These are not included in the summary of the percentage incidence in the acute cholecystitis cases which is shown in the bottom of any of the columns.

†These cases are not included in the total or average as they are duplicated by those of Glass and Moore, 1931, below.

‡This mortality percentage includes 1 case complicated by abscesses and not operated upon. The mortality of the cases operated upon was 26.6 per cent.

perforation of the gall bladder seen at the London Hospital during the 5 year period 1901 to 1925 found in 1,066 gall-bladder operations as shown in Table L. The incidence of perforation of the gall bladder in 130 necropsies on biliary tract cases was found by Colp and Ginsburg to be 6.2 per cent (8 cases, 7 with free perforation and 1 a rupture of a pericholecystic abscess). In a review published after this article was prepared, Hicken and Coray (*Rocky Mountain M J* 1943, 40: 54-529) reported that the incidence of gall-bladder perforation in their series of cases of acute cholecystitis was 35.6 per cent.

#### ANALYSIS OF CASES

The patients in our series of 25 instances of perforated gall bladder were operated upon at the Henry Ford Hospital during the period September 1921 to April, 1943 inclusive.

Sex. Most of our patients—16 or 64 per cent—were females, while 9 or 36 per cent were males. Sanders (1937) reported 46 gall-bladder perforations in 22 females, and 24 males, a sex ratio slightly the reverse of ours. On the other hand 18

of Schaeffer's (1942) 20 cases were females. 10 of Stone and Douglass' 7 cases (1929) were females and Judd and Phillips (1933) reported that 43 of their 61 patients with perforation of the gall bladder were women. The greater incidence in females probably merely reflects the fact that all types of gall-bladder disease are more common in the female sex.

Age. Table II shows that 60 per cent of our cases occurred past the age of 50 years. The average age of the 20 patients reported by Schaeffer in 1941 was 59 years. Judd and Phillips (1933) reported that the oldest of their 61 patients with perforated gall bladder was aged 68 years, the youngest aged 4, but by far the majority of patients were more than 50 years of age. In Stone and Douglass' series (1929) the average age of the patients was 52 years.

Duration of present illness. As shown in Table III the present attack was of less than 7 days' duration in more than half the cases, but in several instances a much larger history was present.

Duration of history of previous attacks. While many of the patients came in with an acute

# COWLEY, HARKINS PERFORATION OF THE GALL BLADDER

TABLE II — AGE

Age in years  
20-29  
30-39  
40-49  
50-59  
60-69  
70-79

No of cases	Percentage
2	8
2	8
6	24
4	16
8	32
3	12

TABLE IV — DURATION OF HISTORY OF PREVIOUS ATTACKS

Duration of history of previous attacks	No of cases	Percentage
None	2	8
0 to 3 months	1	4
3 to 6 months	3	12
6 to 12 months	3	8
1 to 2 years	2	0
2 to 5 years	0	24
5 to 10 years	6	8
10 to 15 years	2	12
Over 15 years	3	4
Yes	1	12
1 or years	2	8

track, most of them (over 90 per cent) complained of previous incidents of gall-bladder disease (Table IV). In many of these cases a history of many years duration was obtained. Practically all of Stone and Douglass' (1939) cases gave a history of pre existing chronic cholecystitis. Elhason and McLaughlin (1934) stated that in all but 1 of their 9 cases a definite history of previous attacks of cholecystitis could be elicited, the duration of symptoms ranging from 18 months to 15 years, and averaging 6 years. Only 3 of the 20 patients with perforation of the gall bladder reported by Schaeffer (1942) complained of symptoms for less than a year. In this series of 20 cases the duration of symptoms varied from 2 weeks to 35 years, but the majority of cases were of long duration.

**Symptoms** Nausea, usually with vomiting, and persistent pain in the right upper quadrant of the abdomen were the commonest symptoms. Radiation to the back occurred in 40 per cent of cases. Stone and Douglass (1939) also reported that all of their cases had pain as their main complaint. Unfortunately, the presence of pain is of little aid in differentiation from acute cholecystitis without perforation.

**Signs** While in most of our cases the white count was elevated (in 32 per cent of the cases it was over 20,000) in 24 per cent it was below 10,000. Wallace and Allen (1941) also found the temperature and white count to be of little value as a guide to the probability of impending perforation. However, Edwards, Gerwig, and Guyton (1941) found the leucocyte count to average around 18,000 to 20,000 in their series of 21 cases. Stone and Douglass (1939) found the average white count to be 14,000. In the series of 20 cases reported by Schaeffer in 1942, in all but one the white count was elevated. As seen in Table VI, elevations of the polymorphonuclear percentage, temperature, pulse, and respirations were of some

TABLE III — DURATION OF PRESENT ILLNESS

Duration of illness	No of cases	Percentage
1 to 3 days	9	36
4 to 7 days	5	20
1 to 4 weeks	4	16
1 to 3 months	3	12
Over 3 months	2	8
Not known	2	8

help, but were not invariable signs. Right upper quadrant tenderness was present in 96 per cent of the cases, a right upper quadrant mass in 24 per cent, generalized abdominal tenderness in 28 per cent, and jaundice in 20 per cent of the cases. The highest icteric index obtained was a reading of 47. In Case 24 this patient had a history of intermittent jaundice for 17 years and 11 operation, besides a gall bladder perforated into the liver and into a chronic pericholecystic abscess, there was an impacted jack-stone type of gall stone in the ampulla of Vater (see Fig 1). Schaeffer (1942) in his series of 20 cases found jaundice to be present exactly as often as we did (20 per cent). Stone and Douglass (1939) in their 17 cases found 6 instances of jaundice (35 per cent).

**Röntgen findings** As seen in Table VII roentgen-ray examination generally showed non-filling of the gall bladder.

**Preoperative diagnosis** In only 12 per cent of the cases was the correct diagnosis of perforated gall bladder even considered in the written diagnosis as is seen in Table VIII. Sanders (1937) reported that a correct preoperative diagnosis was made in only 4 of his 46 cases of perforated gall bladder (9 per cent). Furthermore, Elhason and McLaughlin (1934) stated that "a correct preoperative diagnosis of a perforated gall bladder is quite unusual."

**Classification** The most useful classification is that of Niemeier (1934) who grouped the cases into 3 types as shown in Table IX. Stout and Hibbard (1934) advised another classification, dividing perforations of the gall bladder into five types rather than the three of

TABLE V — SYMPTOMS

Symptoms	Present	Percentage
Pain in right upper quadrant	25	100
Nausea	20	80
Vomiting	18	72
Radiation to back	10	40
Generalized abdominal pain	5	20

TABLE VI.—SIGNS

	No. of cases	Percentage
White count, below 8,000		4
8-10,000	5	20
10-15,000	4	6
15-20,000	6	24
Above 20,000	8	32
Polymorphonuclear per cent.		
below 75	9	36
75-85	4	6
85-90		4
Temperature, normal	3	
98.6-100°	9	36
100-104°	3	
or 5-1°	7	28
Above 103	3	
Pulse, below 90	3	
90-100		40
100-120		4
Above 120		4
Respirations, below 20		4
20-30		24
Above 30		8
Right upper quadrant tenderness	24	96
Right upper quadrant mass	6	24
Generalized abdominal tenderness	7	28
Jaundice	5	20

Niemeyer as follows (1) perforation with communication with another viscus (2) perforation with formation of a pericholecystic abscess (3) acute free perforation (4) perforation into the liver and (5) external perforation.

According to this classification our cases would be classified as type 1 2 cases type 2 16 cases type 3, 6 cases type 4, 1 case and type 5, none.

In Glenn and Moore's series (1942) of 25 cases, type 4 or perforation into the liver was quite common. Sixteen of Sander's (1937) series of 46 perforations had entered the liver.

TABLE VII.—ROENTGEN FINDINGS AT CHOLE CYSTOGRAPHIC EXAMINATION

	No. of cases	Percentage
Non filling	8	32
Non-filling 1b stone shadow	3	
Flat plate negative		4
Unsatisfactory		4
✓ film		43

TABLE VIII.—PREOPERATIVE DIAGNOSIS

	No. of cases	Percentage
Acute cholecystitis	9	36
Chronic cholecystitis	7	28
Empyema of gall bladder		8
Schizophrenic abscess		4
Cholelithiasis and		
suppurative cholangitis	4	
Uncertain or other		8
Ruptured gall bladder	3	

1b case the diagnosis was made after the exploratory laparotomy, in the 16 cases diagnosis of cholelithiasis and in the 16 cases diagnosis of acute cholecystitis with possible rupture was made.

TABLE IX.—GROUPING ACCORDING TO NIEMEYER CLASSIFICATION

Type	No. of Cases	Percentage	Deaths	Mortality percentage
Type 1 Acute free perforation (acute into peritoneal fluid, etc.)		64		15
Type 2 Pericholecystic abscess (subcapsular)		64		
Type 3 Biliary fistula (chronic) into duodenum, into stomach, into liver,				33.3

Free perforations of the gall bladder with generalized peritonitis (type 1 of Niemeyer) represented only 24 per cent of our cases as seen in Table IX. In Table X, it is shown that in the literature these are more common occurring about 75 per cent as often as the localized types. This may not represent the true picture as over half (53 of 99) of these cases were reported by one author (Holtz, 1939). Judd and Phillips (1931) found that only 2 of their 61 cases of perforation of the gall bladder showed extravasation into the general peritoneal cavity. These authors believe that part of this low incidence of generalized peritonitis may be due to the great distances which many of their patients have to travel. Carr (1938) pointed out that free perforations form only a small fraction of the entire group of gall-bladder perforations. The majority of perforations of this viscus occur so gradually that protective adhesions between the gall bladder omentum, and colon are formed, and usually result in a localized abscess. Atlee and Atlee (1949) had

TABLE X.—MORTALITY OF FREE AND LOCALIZED PERFORATIONS OF THE GALL BLADDER

Author	Free perforations		Localized perforations	
	No. of cases	Percentage mortality	No. of cases	Percentage mortality
Niemeyer 1912			6	
Sander, 1937	46	62	24	
Pennington 38	38		—	—
Stones and Dourson, 1939			16	
Holtz, 1939				
Atlee and Atlee, 1949	38			
Glenn and Moore 1942	25			
Schaeffer 1942	42		37	
Cowley and Hartman 1942	26	10	21	
Total or average	98	66.4	1	11

# COWLEY, HARKINS PERFORATION OF THE GALL BLADDER

their 16 cases divided according to Niemeier's classification into type 1 (free perforation), 3 cases, type 2, 11 cases, and type 3, 1 case. Sanders' (1937) ratio was type 1, 4 cases (50 per cent mortality), type 2, 36 cases (55 per cent mortality), and type 3, 6 cases (66 per cent mortality). As seen in Table X, we are the only authors to report a lower mortality in the free perforation series (except Stone and Douglass). We have no explanation for this disparity. Hanley (1936) reported that of his 16 cases of perforation, 5 were associated with generalized peritonitis, 3 with localized peritonitis, and 8 with localized abscess. All of D'Abreu's 3 cases of gall-bladder perforation occurring in 116 gall-bladder cases were of the type associated with generalized peritonitis.

Free perforation is of interest in that it is the only type of peritonitis which will produce "bile peritonitis." In our series of 6 free perforations, in only 4 instances, was the peritoneal fluid bile stained. In none of these was the patient jaundiced. In the other 2 instances only pus was found in the peritoneal cavity. In diagnosing bile peritonitis it is important not to confuse biliary leakage with bile stained ascitic fluid in a jaundiced patient. In only 1 of our 4 cases with peritonitis were red counts or hematocrit determinations made to see if there was hemoconcentration, in this one case erythrocytes were normal.

Harkins, Harmon, and Hudson (1936) studied bile peritonitis experimentally. They pointed out that the two factors hitherto most frequently considered in the literature as important in the production of death in bile peritonitis were the toxic action of absorbed bile and the effects of anaerobic bacteria. In their own experimental studies, data are presented to support the view that the changes commonly found accompanying so called secondary surgical shock are an important lethal factor in bile peritonitis. The mechanism of production of this shock includes an escape of considerable amounts of plasma-like fluid from the injured peritoneal surfaces into the peritoneal cavity with associated hemoconcentration, fall in blood pressure, and decrease in bleeding volume. The condition of surgical shock is not considered to be the entire explanation of death in experimental animals. However, the shock is of such a degree as to make the animal an easier victim of associated toxic and bacterial action.

Clinically this work has little application for four reasons: (1) free perforation of the gall bladder occurs in only a fraction of all gall-bladder perforations, (2) human bile is less concentrated and less irritating than dog bile, (3) in most instances in which the gall bladder is diseased it has

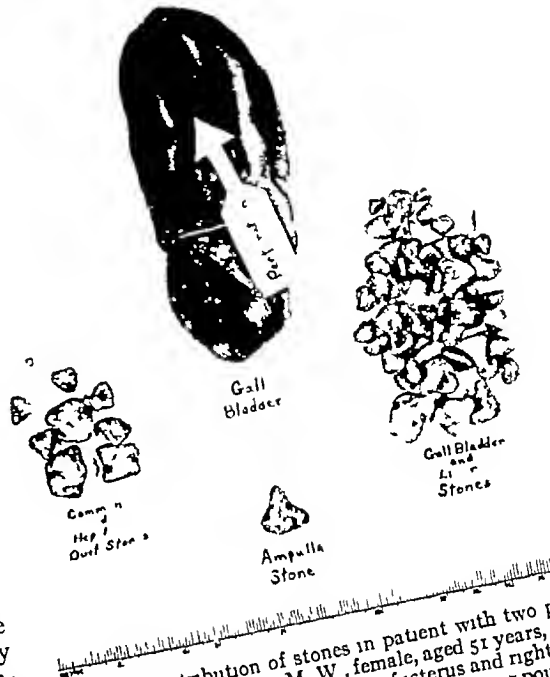


Fig 1 Distribution of stones in patient with two perforations of gall bladder. M W, female, aged 51 years, had complained of intermittent attacks of icterus and right upper quadrant pain for 17 years. Her weight was 227 pounds, per quadrant pain for 17 years. Her weight was 227 pounds, she had marked diabetes mellitus, with icterus index of 47 on admission to the hospital in January, 1943. At operation the gall bladder was found to be packed with stones and about 3 centimeters from the tip of the fundus there was a perforation into the liver, the cavity in the liver contained stones similar to those in the gall bladder. This perforation is marked by the tip of the arrow in the figure, the gall bladder being opened on the peritoneal surface. A second perforation from the right side of the fundus as shown by the white probe entered a pericholecystic abscess containing pus but no stones. The common and hepatic ducts were crowded with stones, which are grouped at the left. A single impacted stone with prongs like a jack stone was present in the ampulla of Vater and had to be removed by a transduodenal approach. Death occurred on 6th postoperative day. Patient's temperature had risen to 109 degrees F despite attempts to protect the liver with glucose and protein.

lost its concentrating power, (4) in many cases when a gall bladder perforates it contains no bile at all. However, in a few cases a true irritative bile peritonitis does occur, and Edwards, Gerwig, and Guyton (1941) stated that perforation into the free peritoneal cavity "initiates a severe chemical peritonitis, which is highly toxic."

In our series we saw no cases of bile peritonitis without demonstrable perforation of the gall bladder as described by Clairmont and Von Haber (1911). Greene and Coe (1940) reported an interesting case of "acute free perforation of the

TABLE VI.—SURGEON PERFORMING OPERATION

Surgeon	No. of cases	Percentage
McClure	9	36
Falls	1	20
Marble	3	
Marshall		8
Davidson		8
Noel		8
Altmeier		4
N. operation, found at necropsy		4

gall bladder occurring twice in the same patient.

Whenever a second type, or perforation with localized abscess formation, is in most series the one most commonly encountered and accompanied by a relatively low mortality. In our 16 cases there were 4 deaths, a mortality of 25 per cent.

The third type, or perforation into a viscus, occurred 3 times in our series, once into the duodenum, once into the stomach, and once into the liver. Perforation into an adjoining viscus occurred in 7 of the 61 cases of Judd and Phillips (1933) (6 into duodenum, 1 into colon). Hoitz (1939) had 6 cases perforate into the colon.

Many of the gall stones which pass from the gall bladder to the intestinal tract by way of fistula cause intestinal obstruction as is well known. Thus, Foss and Summers (1941) reported that gall stones accounted for 4 per cent of all their intestinal obstructions, while gall stone obstruction occurred in 0.3 per cent of all their cases of gall-bladder disease. They reported 6 cases of gall-stone intestinal obstruction and studied 140 additional reported cases. In the large majority of cases in which the fistula was found, it existed between the gall bladder and the duodenum.

Empyema and gangrene are potent factors in the causation of rupture of the gall bladder. Wallace and Allen (1941) stated "Gangrene with perforation is unusual before the sixth day after the onset of symptoms, and "with conservative treatment, even under careful observation in the hospital, gangrene with perforation cannot be anticipated and frequently progressed to a dangerous stage.

Pratt (1933) reported 3 perforations in a series of 15 gangrenous gall bladders with 3 recoveries and 1 death. In their series of 140 patients with

TABLE VIII.—BACTERIOLOGIC STUDIES

Bacteriology	No. of cases	Percentage
Positive culture		4
Bacillus coli	1	
Bacillus lactis aerogenes	1	
Bacillus subtilis	1	
nonhemolytic streptococcus		
Gram + cocci		
Negative culture		8
Culture not recorded		5

\*In some cases these organisms were present in combination. The accounts for the fact that these numbers exceed the total number of positive cultures.

acute cholecystitis operated upon at the U. S. Memorial Hospital during the period from September 1933 to November 1940, McLanahan, Trout, and Weary (1943) reported that there were 24 instances of perforation of the gall bladder (1 per cent). Six of these patients died a mortality rate of 41.8 per cent. Nine of the perforations occurred in the group of 40 cases with gangrene. Thus, gangrene occurred in 25 per cent of the total group of acute cholecystitis.

*Presence of gall stones.* Stones were present in 9 per cent of our cases, 3 cases, and absent in 1 case or 8 per cent. Figure 1 shows a stone not only in the gall bladder but in the ducts, liver and outside of the gall bladder in Case 24. Judd and Phillips (1933) reported that gall stones were present in 56 of their 6 cases of gall-bladder perforation. Sanders (1937) found stones to be present in 42 of his 46 cases of perforated gall bladder (91 per cent). All of Schaeffer's (1942) 20 cases with possible exception had gall stones.

*Type of perforation.* As seen in Table VI the operations were performed by 7 surgeons over a period of 2 years. Table VII shows that in the majority of instances a cholecystectomy was performed. In the literature the preponderance of cholecystectomies done for perforated gall bladder is outstanding.

*Bacteriologic studies.* The 3 most common organisms found in our cases as shown in Table VIII were *Bacillus coli*, *Bacillus lactis aerogenes* and nonhemolytic streptococcus.

*Pathologic studies.* Table IX shows adenocarcinoma present in case acute inflammation in 5 cases, and chronic cholecystitis in 6 cases.

TABLE XII.—TYPE OF OPERATION

Operation	No. of cases	Percentage
Cholecystectomy— with appendectomy with cholecystectomy	7	68
Cholecystectomy		8
Gatch entry of incision		8
Drainage of abdomen		8
Drainage of abscess		4
N. operation, found at necropsy		

TABLE IX.—PATHOLOGIC REPORTS IN 22 CASES OF PERFORATED GALL BLADDER

Pathology	No. of cases	Percentage
Adenocarcinoma		4.5
Gangrene	5	23
Acute cholecystitis	3	13.5
Warty excoriation of chronic cholecystitis	7	31.8
Chronic cholecystitis	6	27.3



crystalline. Our own figures were a little lower in both instances.

2. Our mortality in the 25 cases was 24 per cent in 433 cases of perforated gall bladder collected from the literature it was 20.8 per cent.

3. Of our 25 cases, 6 represented an acute free perforation (Niemöier type 1) 16 a localized pericholecystic abscess (Niemöier type 2) and 3 a perforation into a viscus (Niemöier type 3).

4. The accident was most common in females past 50 years of age with a short present illness, but with a long history of attacks of chronic cholecystitis. Pain in the right upper quadrant, with localized tenderness and in 24 per cent of cases localized mass, along with laboratory evidences of infection or inflammation are helpful in suggesting the diagnosis, but the latter is seldom made before operation.

5. It is difficult to distinguish uncomplicated acute cholecystitis from acute cholecystitis with impending or actual perforation. This difficulty would argue for careful observation of all cases of acute cholecystitis especially in patients over 50 years of age. On the other hand it is impossible to say that our series of cases argues for routine early operation. A review of our 6 deaths indicates that only 5 of these patients might have been saved by earlier operation during the first attack. However 5 of them might have been saved by operation in a free interval after a previous attack since their symptoms were all of long standing.

6. The lesson to be gained from a study of these cases, therefore, is not so much that immediate operation should be performed in acute cholecystitis, although the need for careful observation and individualization is indicated and in many cases early operation should be done after proper preparation, but that interval cholecystectomy should be more frequently done in recurrent cases of chronic cholecystitis.

#### REFERENCES

- ATLEY J. L. and ATLEY, J. L. *Pennsylvania M. J.* 94, 44, 73-734.
- BERNARD MOORE. *Ann. Surg.* 934, 99, 925-929.
- BLALOCK, A. Ball. *Johns Hopkins Hosp.* 924, 25, 30-400.
- BOYCE H. K. and BACKENHURST, C. A. *Am. J. Surg.* 949, 40, 447-453.
- C. VE, H. W. *Surg. Gyn. Obst.* 933, 66, 308-313.
- CHANDROSS, P. and VON HARTMAN, H. *Med. Comm. 9th. Med. Chir.* 9, 54-57.
- COLE, R., and GERSHBERG, L. *Ann. Surg.* 937, 95, 9-22.
- D'ARREY, A. L. *Brit. M. J.* 935, 50-51.
- EDWARDS, C. R. *Gaz. M. H. and Gentry, W. L.* *Ann. Surg.* 941, 3, 814-832.
- FALLIS, L. S. and McCLELL, R. D. *Surg. Gyn. Obst.* 949, 70, 812-832.
- FITZLEIGH, L. R. *Brit. M. J.* 946, 635-636.
- FORD, H. L., and SCHNEIDER, J. D. *Ann. Surg.* 942, 57, 735.
- FRANK, E. L. and McLAUGHLIN, C. W. *Ann. Surg.* 934, 99, 914-921.
- GILMAN, F. *Am. J. Surg.* 934, 99, 86-10.
- JOHN. *Surg. Gyn. Obst.* 934, 69, 41-43.
- GILMAN, F. and MOORE, S. W. *Arch. Surg.* 942, 44, 677-686.
- GRUBER, H. (934). Cited by PENROVER (938).
- GRUBER, R. R. *Am. J. Surg.* 939, 46, 511-501.
- H. VERN, J. L., J. L. *Med.* 939, 8, 33.
- GREENE, L. L. and COLE, G. C. *Surgery*, 940, 7, 306.
- HARRISON, H. N., HARRISON, P. H. and HEDGECOCK, J. *J. Am. M. Ass.* 95, 97, 915-912.
- HARRISON, H. N., HARRISON, P. H. and HEDGECOCK, J. *Arch. Surg.* 935, 43, 570-605.
- HUTCHES, G. J. *Ann. Surg.* 934, 99, 83-89.
- HUTCHES, C. G. *Ann. Surg.* 935, 99, 797-799.
- HUTCHES, R. A. *J. Surg.* 939, 44, 700-7.
- JONES, E. S. and FRIEDMAN, J. R. *Ann. Surg.* 933, 95, 350-361.
- McLAUGHLIN, C. S. TROTT, H. J. and WEARY, W. *Am. J. Surg.* 942, 95, 457-457.
- McCLIMLEY, J. F. and LEWIS, J. J. *Rev. Gastroenterol.* 949, 7, 76-82.
- M. WILLIAMS, C. A. *Ann. Surg.* 9, 2, 55, 11-267.
- MITCHELL, E. D. *Br. Ann. Surg.* 925, 93, 700-701.
- MURPHY, E. H. *Surg. Gyn. Obst.* 936, 8, 879-886.
- MULLER, R. H. (930). Cited by Gilman (930).
- NELSON, O. B. *Ann. Surg.* 934, 99, 9-224.
- NOT, J. T. Cited in discussion of paper by McClimley and Lehman (940).
- PENROVER, G. P. *Ann. Surg.* 938, 97, 545-557.
- PRATT, O. H. *Am. J. Surg.* 935, 46-5.
- RENN, C. *Am. J. Surg.* 942, 95, 385-397.
- R. COLE, R. L. *Surgery* 937, 940-958.
- SCHWARTZ, R. L. *Postgrad. Med. J.* 942, 45, 560-569.
- SMITH, M. K. *Am. J. Surg.* 938, 50, 92-106.
- STONE, W. W. *J. Am. M. Ass.* 937, 99, 902-904.
- STONE, W. W. and DOUGLASS, F. M. *Am. J. Surg.* 936, 45, 304-307.
- STOUT, S. L., and HARRISON, J. E. *Surgery* 943, 3, 734-740.
- TODD, M. S. *Chian. M. J.* 91, 45, 966-970; *Abstr. J. Am. M. Ass.* 937, 95, 444.
- WALLACE, R. H., and ALLEN, A. W. *Arch. Surg.* 904, 45, 762-77.
- WALTON, A. J. (932). Cited by Gilman (930).
- ZIMMERMAN, M. (932). Cited by Gilman (930).

# VOLVULUS OF THE SIGMOID COLON

Discussion of Combined Volvulus and Hepatodiaphragmatic Interposition  
J G PROBSTEIN, M D, F A C S, and H R SENTURIA, A B, M D, Captain, M C, A U S,  
St. Louis, Missouri

THE occurrence of volvulus in this country is relatively infrequent. By contrast, sigmoid volvulus occurring as an acute abdominal emergency is very common in Russia and Germany. Perlmann, reporting from his clinic in Russia, states that over 50 per cent of intestinal obstruction is found to be caused by volvulus. The frequency of redundant colons is attributed by most authors to a coarse vegetable diet rich in undigestible cellulose which makes a great demand on the pelvic colon as a fecal storehouse. Although in most cases an unusually long, mobile mesocolon is recognized as the fundamental basis of volvulus, megasigmoid, with or without megacolon, abnormalities in rotation of the bowel, bands, adhesions, or tumors may also be factors. In 1 of the cases herein reported hepatodiaphragmatic interposition of the colon was present in addition to a volvulus of the megasigmoid, 2 relatively uncommon and usually distinct conditions.

CASE 1 B M, a 32 year old white male, born in Russia, was admitted to the hospital February 2, 1941. His chief complaint was abdominal pain of 12 hours' duration. The patient was a known diabetic under control without the use of insulin. About 1 month before admission the patient had a transitory attack of grippe, lost weight, and felt under par. On the evening before admission upper abdominal pain without nausea or vomiting. He had two small bowel movements. The following morning he gave himself an enema with very poor results. On the day of admission he vomited small amounts of undigested food, three times. No blood was observed in the vomitus or stool.

Physical examination revealed a pale, acutely ill male, with temperature, pulse, and respirations normal. The examination was negative except for the abdomen which was distended, soft, with no rigidity or hyperesthesia. Rebound tenderness was absent. Several hours after admission the pain became more severe and seemed to localize in the center of the abdomen. The vomiting became more profuse and consisted of copious amounts of brown, undigested, semiliquid material. Re-examination of the abdomen revealed what appeared to be an obliteration of liver dullness. This had not been noticed on previous examination. When he was rolled from side to side, or when the right upper quadrant was stroked with the hand,

a splashing sound could be heard. The abdomen continued to be slightly distended and felt doughy rather than rigid. Roentgenograms were made with the patient in various positions, and, in the absence of the roentgenologist, were interpreted as showing free air under the right dome of the diaphragm resembling a spontaneous pneumoperitoneum due to a perforated hollow intra-abdominal viscus.

In spite of the lack of clinical findings to corroborate the roentgen interpretation, exploratory laparotomy was performed about 9 hours after admission to the hospital. When the peritoneum was opened there was no escape of free air. A moderate amount of free, clear straw colored fluid was present. Further examination showed a large, dilated loop of bowel on the right side of the abdomen. In the delivery of the loop, detorsion occurred and further investigation proved this loop to be an unusually large sigmoid. The bowel was so mobile it could be taken completely out of the abdomen. It resembled an inflated inner tube. The bowel was somewhat injected and contained a great deal of fluid and hard fecal masses. When it was made certain that the obstruction was relieved, the bowel was replaced in the left quadrant and the abdomen was closed.

A review of the films the following morning made possible the recognition of the hepatodiaphragmatic interposition of the colon which complicated the sigmoid volvulus. A film of the abdomen with the patient upright to show the diaphragm (Fig. 1) demonstrated the absence of the liver shadow beneath the right dome of the diaphragm, while on the left, a distended colon containing considerable stool was identified by the broad haustral septa. A film made with the patient in the left lateral recumbent position showed a column of air (Fig. 2) between the liver shadow and the right lateral abdominal wall and diaphragm. This column of air was traversed by a solitary haustral band which immediately identified the air as being colonic and not free in the peritoneal cavity.

The patient's postoperative course was complicated by a few patches of atelectasis which responded to conservative treatment, and he went on to complete recovery. On June 6, 1941 he was readmitted to the hospital with the interval history that he had been fairly well except for marked constipation. On the afternoon of this admission he was seized with severe cramping epigastric pain of increasing severity which radiated down to the umbilicus. His bowels had not moved for 3 days and he had vomited. He gave himself an oil retention enema which he expelled with some stool and flatus affording considerable relief. Examination on admission to the hospital showed him to be poorly developed and acutely ill. The abdomen again was distended, doughy to palpation, and diffusely tender. There was no rebound pain or muscle guard. Tympany could be elicited over the entire abdomen. Roentgenograms made on this admission showed an appearance identical with the films on the initial admission. Hepatodiaphragmatic interposition of the colon was again demonstrated. The patient was treated conservatively with repeated enemas, and his abdominal pain and vomiting was relieved. A barium enema was given in order to identify

From the Departments of Surgery and Roentgenology, Jewish Hospital of St. Louis and the Department of Surgery, Washington University School of Medicine, St. Louis, Missouri.  
Aided by the Louis M. Monheimer Research Fund



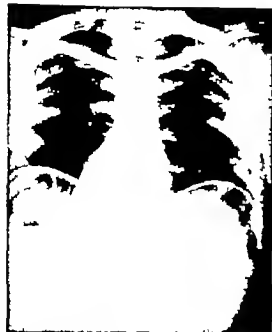


Fig. 3. Film of abdomen (14 patient upright) illustrating the absence of liver shadow beneath right dome of the diaphragm.



Fig. 4. Patient in left lateral recumbent position shows collection of air beneath the liver (right lateral) and diaphragm.

and locate the bowel in the right upper quadrant, but at the start of the enema preliminary survey showed that the interposition had spontaneously reduced itself. The barium enema, as given, however, and as unusually long redundant sigmoid flexure as found, base upper extremity lay immediately beneath the under surface of the liver. The remainder of the large bowel, as generally dilated (Fig. 3) and as the colonos of barium progressed to the hepatic flexure the sigmoid loop, as displaced downward by the distended transverse and ascending colon segments, which lay external to, and above, the sigmoid bend. With the obstruction again relieved, operative measures were recommended to the patient but were refused.

On June 20, '94, he was readmitted because of repeated attacks of abdominal pain and constipation as on his first and second admissions to the hospital. The patient now consented to operative intervention. Under spinal anesthesia an obstructive resection of the redundant dilated sigmoid loop was performed (Fig. 4). His postoperative course, as uncomplicated and several months later he was readmitted for closure of the colostomy opening, with good results.

**CASE A. C.** colored male, 36 years of age, laborer was admitted to the Homer Phillips Hospital July 9, '94, with the history of colicky, cramplike, generalized recurrent abdominal pain, which began 36 hours before admission. The patient was nauseated and vomited once. Self-medication consisted of vinegar soda bicarbonate and opium salts, which resulted in very small liquid stool.

Physical examination on admission showed, well developed, and well nourished negro male lying in bed with both knees flexed, holding his abdomen with both hands. The abdomen, as symmetrically distended and generally

tender to deep palpation. There were no masses or areas of localized tenderness. The act of examination produced generalized colicky, bilobed pain. There was no fluid wave or visible peristalsis. There was audible peristalsis at intervals of 3 to 4 minutes. An x-ray examination shortly after admission showed gross distention of the small intestine in the upright position with definite fluid level. There was no free gas.

Operation 24 hours after admission, under spinal anesthesia, showed moderate amount of blood stained free fluid in the peritoneal cavity. The sigmoid colon, as found to be greatly enlarged, redundant, and extended across the mid line and above the umbilicus to the upper right quadrant. The bowel and the adjacent mesentery were found to be tangled upon themselves. The color of the bowel, as good. The sigmoid loop was unwound and decompressed by rectal tube and as replaced in the left colonic gutter. Further exploration of the abdomen revealed nothing of note. *Diagnosis:* *obstruction of megacolon.*

The postoperative course, as complicated by pulmonary infection, both responded readily to therapy. The patient, as out of bed on the 5th postoperative day and as discharged on the 5th postoperative day after refusal to submit to resection of the redundant sigmoid, which he, as urgently advised to undergo.

He remained entirely free of symptoms until July 9, 1922, almost a year following his initial attack, when he was admitted to the service of Dr. Carl J. Hefetz complaining of crampy abdominal pain of 24 hours duration. He complained of desire to defecate but was unable to do so. The last normal bowel movement had been 3 days before admission. The patient had been nauseated and vomited once on the 4th of the hospital. The abdomen





Fig. 1. Film of abdomen. (1st patient upright) illustrating the absence of liver shadow beneath right dome of the diaphragm.



Fig. 2. Patient in left lateral recumbent position showing column of air beneath the liver shadow on the right lateral side and diaphragm.

and locate the bowel in the right upper quadrant, but at the start of the caecum preliminary survey showed that the interposition had spontaneously reduced itself. The barium caecum, as given, however, said as unusually long redundant sigmoid flexure as found lower upper extremity lay immediately beneath the under surface of the liver. The remainder of the large bowel, as generally dilated (Fig. 3) and as the column of barium progressed to the hepatic flexure the sigmoid loop, as displaced downward by the distended transverse and ascending colon segments, each lay external to, and above, the sigmoid bend. With the obstruction again relieved, operative measures were recommended to the patient but were refused.

On June 30, '94, he was readmitted because of repeated attacks of abdominal pain and constipation as on his first and second admissions to the hospital. The patient now consented to operative intervention. Under spinal anesthesia an obstructive resection of the redundant dilated sigmoid loop was performed (Fig. 4). His postoperative course was uncomplicated and several months later he was readmitted for closure of the colostomy stoma, with good results.

**CASE 3.** C. colored male, 36 years of age, laborer was admitted to the Homer Phillips Hospital July 9, '94, with the history of colicky cramplike, generalized recurrent abdominal pain which began 36 hours before admission. The patient was nauseated and vomited once. Self medication consisted of vinegar soda bicarbonate, and epsom salts, which resulted in very small liquid stool.

Physical examination on admission showed all developed, and all nourished negro male lying in bed with both knees flexed, holding his abdomen with both hands. The abdomen was symmetrically distended and generally

tender to deep palpation. There were no masses or areas of localized tenderness. The act of examination produced generalized colicky abdominal pain. There was no fluid or visible peristalsis. There was audible peristalsis at intervals of 3 to 5 minutes. An x-ray examination shortly after admission showed gaseous distention of the small intestine in the upright position with definite fluid level. There was no free gas.

Operation 24 hours after admission, under spinal anesthesia, showed moderate amount of blood tinged free fluid in the peritoneal cavity. The sigmoid colon, as found to be greatly enlarged, redundant, and extended across the mid line and above the umbilicus to the upper right quadrant. The bowel and the adjacent mesentery were found to be inflated upon themselves. The color of the bowel was good. The sigmoid loop was excised and decompressed by rectal tube and was replaced in the left colonic gutter. Further exploration of the abdomen revealed nothing of note. Diagnosis: oblique of megacolon.

The postoperative course was complicated by pulmonary infection, which responded readily to therapy. The patient was out of bed on the 5th postoperative day and was discharged on the 5th postoperative day after refusal to submit to resection of the redundant sigmoid which he was urgently advised to undergo.

He remained entirely free of symptoms until July 2, '95, almost a year following his initial attack, when he was admitted to the service of Dr. Carl J. Hefkens complaining of cramplike abdominal pain of 24 hours duration. He complained of desire to defecate but was unable to do so. The last normal bowel movement had been 3 days before admission. The patient had been nauseated and vomited once on the way to the hospital. The abdominal

# EDITORIALS

## SURGERY Gynecology and Obstetrics

FRANKLIN H. MARTIN  
Founder and Managing Editor  
1905-1935

LOYAL DAVIS, EDITOR

Associates

MICHAEL L. MASON

SUMNER L. KOCH

DONALD C. BALFOUR, Associate, Editorial Staff

DECEMBER, 1943

### TOTAL HYSTERECTOMY

COMPLETE hysterectomy is being performed with increasing frequency in the treatment of lesions involving the uterus, whether the process be benign or malignant. Some surgeons always perform the total variety of hysterectomy. It is the belief of some surgeons that every patient possessing a diseased cervix in association with other uterine conditions, even though no malignant process is present, should have a total hysterectomy. Many arguments in favor of such a routine procedure have been advanced, some have been raised in opposition.

Obviously, the chief advantage of the total operation is that the cervix, the possible site of infection or neoplasm, is removed. Probably that is the sole point in its favor. The question arises whether the advantage of eliminating the cervix outweighs the disadvantages of increased mortality and morbidity. The incidence of stump cancer is variously stated. Von Graff places it at 0.62 per cent among 7,244 subtotal hysterectomies. While

there is great difficulty in determining the exact incidence yet it is fair to assume that cancer has already been present if it appears in the cervix in the first year after a subtotal hysterectomy. Ward, in a report covering the twenty year period prior to 1940, gives the incidence of stump cancer occurring at the Women's Hospital in New York as 6.9 per cent. His findings, as well as those of others who have recently written on the subject, strongly suggest that the condition occurs more frequently than we had first thought. Since Spencer, in 1902, first called our attention to the frequent coincidence of malignant tumors involving the cervix with fibroids involving the corpus, innumerable references to the matter have been made and provide additional arguments for the proponents of total hysterectomy.

As Martzloff recently pointed out in this Journal, "the major issue seems to be whether, when abdominal hysterectomy is performed for benign disease, total hysterectomy should be employed as an inflexible routine in order to forestall the possibility of future malignant change which, presumably, exists as long as there is the slightest cervical residuum."

All writers agree that total hysterectomy may be accompanied by a higher incidence of postoperative hemorrhage, shock, damage to the bladder, ureters, and rectum, cystitis, pelvic cellulitis, wound infection, phlebitis, and thrombosis. Nearly all, however, conclude that such complications are no more common with the total operation than with supra-cervical hysterectomy provided the operation is expertly performed.

Nearly all surgeons accept the proposition that neither the total nor the subtotal opera-

serious surgical emergencies. Chief among these is spontaneous pneumoperitoneum due to perforation of a hollow viscus, and right sided subphrenic abscess. The difficulties which can be encountered in this connection are illustrated by the reports of Pendergrass and Kirk. They reported a case of hepatic interposition of the colon which was mistaken for free air in the peritoneal cavity. At operation, there were no signs of a perforated viscus, but rather an acute pancreatitis was found. Schenck reported a case of a 45 year old negro who had both a spontaneous pneumoperitoneum due to a perforated prepyloric ulcer and hepatic interposition of the colon. A distinct fluid level was present on the films made with the patient in the erect position, while those made in the recumbent position showed the haustral septa of the gas-filled distended colon.

Volvulus may occur in the sigmoid-ecum and in the small intestine. The most common site is the sigmoid.

The symptoms of volvulus simulate closely the findings of other obstructive lesions of the colon or small intestine depending on the acuteness or chronicity.

Volvulus of the sigmoid shows a decided tendency to recur. Bloodgood reports a case in which there were 32 attacks or recurrences in one individual in a space of 16 years.

Untwisting the bowel in a case of volvulus accomplishes nothing toward removing the predisposing

or etiological factors. Statistics appear to indicate that once volvulus takes place recurrence is more likely to occur than before. A simple untwisting and replacement of the bowel into its normal abdominal position appears to be insufficient. Since shortening of the mesentery sigmoidectomy and other procedures have not produced satisfactory results, it is our opinion that an immediate obstructive resection should be attempted at the primary exploration if it is possible. This will obviate a subsequent operation.

#### SUMMARY

Two cases of recurrent volvulus of a sigmoid megacolon one with hepatodiaphragmatic interposition of the sigmoid colon are reported. The presence of an unusually long mobile sigmoid is the basic factor for the simultaneous occurrence of a relatively uncommon and usually distinct pathological condition, namely volvulus and hepatodiaphragmatic interposition.

Immediate resection of the sigmoid should be performed for volvulus when it is at all feasible.

#### REFERENCES

- BLOODGOOD, J. C. *Ann. Surg.* 909, 49, 61.
- CORLIARDI, D. *Fortsch. Roentgenstrahl* 910-9
- KOLFF, K. J. *Am. J. Roent.* 935, 30, 9-936
- PENDERGRASS, E. P. and KIRK, E. *Am. J. Roent.* 936, 35-245
- PERLMAN, J. *Arch. Clin. Chir.* 95, 37, 245
- SCHENCK, S. G. *Arch. Surg.* 935, 30, 766-777

# EDITORIALS

## SURGERY Gynecology and Obstetrics

FRANKLIN H. MARTIN  
Founder and Managing Editor  
1905-1935

LOYAL DAVIS, EDITOR

SUMNER L. KOCH Associates  
MICHAEL L. MASON

DONALD C. BALFOUR, Associate, Editorial Staff

DECEMBER, 1943

### TOTAL HYSTERECTOMY

COMPLETE hysterectomy is being performed with increasing frequency in the treatment of lesions involving the uterus, whether the process be benign or malignant. Some surgeons always perform the total variety of hysterectomy. It is the belief of some surgeons that every patient possessing a diseased cervix in association with other uterine conditions, even though no malignant process is present, should have a total hysterectomy. Many arguments in favor of such a routine procedure have been advanced, some have been raised in opposition.

Obviously, the chief advantage of the total operation is that the cervix, the possible site of infection or neoplasm, is removed. Probably that is the sole point in its favor. The question arises whether the advantage of eliminating the cervix outweighs the disadvantages of increased mortality and morbidity.

The incidence of stump cancer is variously stated. Von Graff places it at 0.62 per cent among 7,244 subtotal hysterectomies. While

there is great difficulty in determining the exact incidence yet it is fair to assume that cancer has already been present if it appears in the cervix in the first year after a subtotal hysterectomy. Ward, in a report covering the twenty year period prior to 1940, gives the incidence of stump cancer occurring at the Women's Hospital in New York as 6.9 per cent. His findings, as well as those of others who have recently written on the subject, strongly suggest that the condition occurs more frequently than we had first thought. Since Spencer, in 1902, first called our attention to the frequent coincidence of malignant tumors involving the cervix with fibroids involving the corpus, innumerable references to the matter have been made and provide additional arguments for the proponents of total hysterectomy.

As Martzloff recently pointed out in this Journal, "the major issue seems to be whether, when abdominal hysterectomy is performed for benign disease, total hysterectomy should be employed as an inflexible routine in order to forestall the possibility of future malignant change which, presumably, exists as long as there is the slightest cervical residuum."

All writers agree that total hysterectomy may be accompanied by a higher incidence of postoperative hemorrhage, shock, damage to the bladder, ureters, and rectum, cystitis, pelvic cellulitis, wound infection, phlebitis, and thrombosis. Nearly all, however, conclude that such complications are no more common with the total operation than with supra-cervical hysterectomy provided the operation is expertly performed.

Nearly all surgeons accept the proposition that neither the total nor the subtotal opera-

tion should be recommended as a routine procedure also nearly all agree that the total operation would be preferred were it not that it takes longer to perform that it requires greater skill and that as revealed from accumulated figures from unselected clinics, it is accompanied by higher mortality.

Many experienced surgeons disagree with those who contend that the cervix can be adequately treated either before or after a sub-total hysterectomy by such procedures as trachelorrhaphy, cauterization, or low amputation. Von Graff has reported 37 cases of cancer developing in cervical stump following partial hysterectomy even after the cervix had been cauterized, or coned, at the time of the hysterectomy.

If total hysterectomy were performed routinely by all surgeons, by those of great skill as well as by those of limited experience mortality undoubtedly would be high. The surgeon who performs six or eight hysterectomies a year should confine himself to the supracervical procedure yet the surgeon who performs, annually, a hundred or more should be able to carry out the total operation expertly and with a mortality no greater than that of any surgeon who adheres to the less formidable procedure. It is probably true that if all hysterectomies were of the complete type the ultimate mortality would be greater than it is at present with supravaginal hysterectomy plus those cancer deaths resulting from neoplastic disease developing in the retained cervix.

We agree with the many writers who have studied the questions and who state that it does not necessarily mean that "total abdominal hysterectomy is a dangerous and radical operation when performed by one experienced and proficient in pelvic surgery." It is not an operation for the occasional operator. It is an operation for a thoroughly trained and ex-

perienced surgeon. With him it is a safe procedure and with the majority of patients requiring a hysterectomy total hysterectomy is the best procedure.

While the value of total hysterectomy in the prevention of cervical cancer is accepted the presence of benign disease plus the possibility of subsequent cancerous change is not an incontestable indication for pan-hysterectomy if the procedure is to be accompanied by increased operative risk and result in higher mortality than would follow if the hysterectomy were of the supracervical type. The question of which procedure to elect resolves itself therefore largely into a matter of degree of surgical experience and technical skill.

HAROLD L. Foss

## ACUTE CHOLECYSTITIS—WHY OPINIONS DIFFER AS TO TREATMENT

**M**OST of the present confusion in the care of acute cholecystitis has arisen from the difficulty in defining what is meant by "acute cholecystitis" and by "early operation." Acute cholecystitis has been used by some authors to denote an acute attack of pain in the gall-bladder region or pain plus other clinical and laboratory findings or merely a pathological picture seen in microscopic sections. "Early operation" to some surgeons means early in the course of the disease while most writers mean a prompt intervention after the patient has entered the hospital which may be seven or eight days after the onset.

To the clinician an agreement on a few definitions would aid greatly in the care of these cases. Let us assume that an "early operation" is one performed within 48 hours of the onset of the acute symptoms that a "moderately early operation" is one undertaken

## EDITORIALS

only after the clinical signs and symptoms have subsided

From a practical standpoint, it would be better to substitute the term "acute gall bladder attack" for "acute cholecystitis." This would include gall-stone colic, edema of the gall bladder, and true, well established, "acute cholecystitis."

A clear picture of the usual sequence of pathological events in these conditions is of great value in a study of their treatment. Clute's description appeals very strongly to me. He believes that acute gall-bladder disease usually is not caused by infection, but that it often starts with the impaction of a stone in the entrance to the cystic duct, that edema occurs from pressure and that branches of the cystic artery are occluded with localized or general gangrene in about 20 per cent of the hospital cases.

Perforation is not uncommon. Some authors place perforation at over 10 per cent in the acute cases when patients come to operation late in the disease. Infection is seldom an important factor within 48 hours of the onset. The outcome in an individual patient, while under observation, cannot be accurately predicted nor can the exact pathological condition present in the gall bladder be determined by the surgeon before operation. Touroff, Elhason, Judd, Roscoe, Graham, Fallis and McClure, Pennoyer, Heuer, Glenn, and many others confirm this statement. In more than one-half the cases, the disease is a progressive and not a regressive one. Delay leads to serious irreversible changes and increased mortality. When operation is performed within 48 hours of the onset infection is negligible, death will seldom follow unless perforation or pancreatitis is already present or the patient has had many previous attacks or is old and feeble. Delay will not save the patient with the fulminating type of disease, nor will it help the aged or the patient with diseased organs.

In the early cases adequate preparation can usually be made within a few hours after the patient enters the hospital. The operation if done within 48 hours is not a dangerous one, usually it is best to remove the gall bladder from above downward. Some modification of the usual total cholecystectomy may be preferable in some cases as recommended by Heyd, but, in spite of Cutler and Zollinger's splendid mortality figures, I agree with Heyd that a cholecystostomy should seldom be performed. Cholecystectomy removes the disease and the postoperative course is smooth, complications are few and the time in the hospital is short. The mortality should be under 4 per cent. I cite Pratt, Heuer, Glenn, Finsterer, the Post Graduate Hospital series, excluding those cases in which acute pancreatitis was already present at operation, and the series of 167 early cases collected by Graham and Hoeffle. Patients in the group of moderately early cases, those seen within five days, do well with a little preparation but operations performed a week or more after the onset have a high mortality, hence, each such patient must be individually studied. They have suffered from pain, loss of sleep, and lack of food. They may be anemic and dehydrated, and other organic disease may have been aggravated. Careful preparation must be made with fluids, narcotics, transfusions, food, if possible, and all other necessary measures should be taken. Then the decision must be made whether to operate or delay. No rule can be laid down as to the proper time for operation in these late cases.

How do these opinions agree with those found in our surgical journals? Touroff analyzed 75 proved cases of acute cholecystitis in which patients were treated by delayed operation, in 42 per cent operation revealed the presence of pus, gangrene, or perforation.



What is meant by "acute cholecystitis"? Let me attempt to show how difficult it is to answer this question. Pennoyer reviewed the Roosevelt Hospital cases using a clinical yard stick consisting of pain, temperature of 101 degrees, a leucocytosis of 12,000 or over muscle spasm and tenderness. Cases of gall stone colic without fever or leucocytosis were excluded, and he frankly states that several cases with an old rupture and localized abscess were not included because they had no fever no leucocytosis and no acute symptoms except perhaps tenderness and muscle spasm. Personally I feel that one individual may run the whole gamut of variations starting with gall-stone colic and ending with gangrene and perforation as the disease progresses.

Cave says, "It is observed that immediate operation in our hands gave a mortality rate of 20 per cent." It is evident from his paper that immediate operation was practiced only on the critically ill whose condition was not improving. Delay seemed dangerous so operation could not be avoided. Naturally the mortality would be high in this selected bad risk group. Speaking of the delayed operation he adds "It is striking to note the smooth convalescence of patients operated upon when gangrene perforation and localized abscess have ensued. What a humiliating thought it is that gangrene perforation, and abscess should be present at operation in any gall bladder case. This is no criticism of the authors of these papers for they are scholarly well written and honest presentations of the material analyzed.

Falla and McClure had similar difficulties. They studied only those cases on which a pathological diagnosis of acute cholecystitis

had been made and concluded that the best results were obtained by deferring operation until 72 hours had elapsed. They state however "This excluded from our review many cases in which a diagnosis of acute cholecystitis had been made by both the clinician and the operating surgeon. If these cases of simple edema of the gall bladder which accompanies gall-stone colic had been included, our results would have been materially affected and a brief for rather than against, immediate operation would have been presented."

Is it not evident that this simple edema of the gall bladder that they mentioned is often an early stage of acute cholecystitis and that operation in this stage is safer and better than one when real pathological evidence of poly nuclear infiltration of the gall bladder is present?

Roscoe Graham introduces the term "urgent operation" and argues against it. He states that the average length of time from onset to admission to their hospital was six days. He makes this significant statement "That one can submit to operation within the first 48 hours a very large percentage of patients suffering from severe and persistent biliary colic, with a very low operative mortality is not surprising. He also says "Persistent biliary colic produces an acute cholecystitis. Would it not be better if patients with acute gall-bladder disease could be persuaded to enter the hospital much sooner than six days on an average and then have a prompt operation.

The time will come when an educated profession and an educated public will demand a prompt operation early in these acute gall-bladder attacks.

HENRY F. GRAHAM.

# THE SURGEON'S LIBRARY

## REVIEWS OF NEW BOOKS

EVERY urologist, veteran or neophyte, will wish to read carefully and keep *Transurethral Prostatectomy*<sup>1</sup> by Reed M. Nesbit in his library for continued reference. It ably illustrates the modern advances which have been achieved in the development of a transurethral method for relieving prostatic obstruction. This method has been the subject of monographic reports on several occasions since Guthrie published his work in 1834. From a wealth of personal experience Nesbit has been able to outline in detail the methods which have given him satisfactory and permanent results. The modern instruments adapted to this procedure have, in the main, been perfected by American urologists and manufacturers. Nesbit has developed a modification of the Stern-McCarthy instrument and, while his technique is largely based on the application of his own method of removing tissue, his ideas and suggestions can be wisely utilized by any surgeon familiar with transurethral prostatic resection while using any other suitable type of instrument. This book is prefaced by a chapter on the arterial distribution within the prostate gland and its significance in transurethral resection. A careful study of this chapter by Rubin H. Flocks will be most instructive for anyone who is hopeful of becoming proficient in this branch of surgery. Armamentarium, the use of the resectoscope, diagnosis and selection of patients for operation, suitable anesthesia, and the technique of actual tissue removal are discussed in detail. The illustrations of William P. Didusch represent the application of a knowledge and skill in urological drawing acquired during a quarter of a century. They add greatly to the value of the text.

In the discussion on preoperative management the subject of "water balance," so important in the proper care of patients with prostatic obstruction, is covered in a noteworthy manner. Since much of the investigative and clinical data on this subject originated at the University of Michigan Hospital the conclusions are most authoritative.

Modern developments in the management of prostatic malignant tumors by orchiectomy or estrogen therapy are reviewed in a manner which is both clear and concise.

Nesbit's final evaluation as to the efficacy of transurethral prostatectomy sums up to a most satisfactory personal experience, with low mortality and morbidity, and a high percentage of excellent urinary function on the part of the great majority of his patients.

VINCENT J. O'CONNOR

<sup>1</sup>TRANSURETHRAL PROSTATECTOMY. By Reed M. Nesbit M.D. F.A.C.S. Springfield Illinois: Charles C. Thomas, 1943.

THE second edition of *Outline of Roentgen Diagnosis*<sup>2</sup> by Dr. L. G. Rigler has been brought up to date and includes all of the latest changes. Some of the subject matter has been rearranged. The first edition has proved an excellent textbook for medical students. It is concise and well arranged. The new edition should prove even more useful. The only criticism is regarding the illustrations which have not been changed, they are too small and the reproductions are not too good.

R. G. WILLY

A MOST interesting account of the contributions of the medical department of the United States Army to medical progress has been written by Colonel Hume<sup>3</sup>. This book will be of interest to the layman as well as members of the medical profession. It should be of especial interest to doctors now on duty with our armed forces.

All America is familiar with the work of Major Walter Reed in the study of yellow fever, of Major William Crawford Gorgas and his sanitation of the Panama Canal Zone. Known to medical students is the work of Surgeon William Beaumont in his study of the digestive processes of the stomach through the permanent gastric fistula of the half-breed Alexis St. Martin. Little known interesting facts regarding American medicine add to the interest of this book. The first American textbook on surgery bearing the interesting title *Plain Concise Practical Remarks on the Treatment of Wounds and Fractures, To which is added a Short Appendix, on Camp and Military Hospitals, Principally designed for the use of Young Military and Naval Surgeons in North America*, was written by the American military surgeon, John Jones, and printed in 1776. The history of the establishment of the Army Medical Library and its *Catalogue* is most interesting, considered by Dr. William Henry Welch as America's greatest contribution to medicine. Few of us realize that this is the world's greatest collection of medical books and associated with the library is the Army Medical Museum, the world's largest. Colonel John Shaw Billings was not only the originator of the *Index Catalogue of The Library of the Surgeon General's Office of the United States Army*, and probably the greatest medical officer our Army has ever had, but he also originated the *Index Medicus*, later consoli-

<sup>2</sup>OUTLINE OF ROENTGEN DIAGNOSIS. AN ORIENTATION IN THE BASIC PRINCIPLES OF DIAGNOSIS BY THE ROENTGEN METHOD. By Leo G. Rigler, B.S., M.B. M.D. 2d ed. Philadelphia, London Montreal: J. B. Lippincott Co. 1943.

<sup>3</sup>VICTORIES OF ARMY MEDICINE. SCIENTIFIC ACCOMPLISHMENTS OF THE MEDICAL DEPARTMENT OF THE UNITED STATES ARMY. By Edgar Erskine Hume, Colonel. Medical Corps United States Army. Philadelphia: J. B. Lippincott Co. 1943.

dated with the *Quarterly Cumulative Index* to be known the *Quarterly Cumulative Index Medicus*. Billings designed Johns Hopkins and Peter Bent Brigham Hospitals and others, and made many other contributions to American medicine.

Surgeon General George Miller Sternberg was one of America's foremost scientists. Among his many accomplishments he established the Army Medical School and discovered the micro-organism of pneumonia. And so this book unfolds the accomplishments of the medical department of the United States Army—one department at least that was prepared at Pearl Harbor on December 7, 1941 when the Japs attacked.

The author Colonel Edgar Erskine Hume, writes in smooth and interesting style. He is well qualified to write such a chronicle. He was in charge of the Second Commission to study typhus fever in Serbia. He has written several scientific papers and was Librarian of the Army Medical Library from 1933 to 1936. EARL Q. LAMORE.

THE second edition of the excellent book *A Manual of Otolaryngology and Laryngology*

A MANUAL OF OTOLARYNGOLOGY AND LARYNGOLOGY. By Howard C. Ballenger, M.D., F.A.C.P. Philadelphia, Col. & Foreign, 1943.

by Ballenger contains many changes and additions which bring it up to the present day knowledge. Among the new additions is a chapter covering foreign bodies in the air and food passages. There also is a detailed description of the surgical technique of tracheotomy which is as a rule emergency measure so should be known to every practitioner. Dr. John F. Ballenger has rewritten the chapter on parathyroid and neurosis of the larynx. This revision has been so well done that it deserves special commendation.

Unlike many other books on this subject, the author stresses the anatomy, etiology, pathology, diagnosis, symptoms, and treatment both general and local. The prognosis is discussed briefly and only in those conditions which are thought to be necessary. Descriptions and discussions of the various surgical techniques are purposely omitted from the text.

This compact book is well written and fully illustrated describing briefly all diseases of the ear, nose, and throat and in sufficient detail to give a clear conception of the subject. The specialist practitioner and the student as well will find the book most valuable source of information.

L. F. McBRIDE

## BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

THE EAR, NOSE AND THROAT IN THE SERVICE. By R. Scott Stevenson, M.D., F.R.C.S. (Ed.) M. for R.A.M.C. Oxford War Manual. Edited by The Rt. Hon. Lord Horder, G.C.V.O. London: Oxford University Press (Hempstead Millard), 1943.

LEICHELDOUGLAS THE WEATHER AS DESTINY. By William F. Peterson. Springfield, Ill. and Baltimore, Md. Charles C. Thomas, 1943.

FRACTURES AND DISLOCATIONS FOR PRACTITIONERS. By Edwin O. Geckeler, M.D. 3d ed. Baltimore: The Williams & Wilkins Co., 1943.

TEXTBOOK OF SURGICAL TREATMENT, INCLUDING OPERATIVE SURGERY. Edited by C. F. W. Mearns, M.D., Ch. M. F.R.C.S.E. Baltimore: The Williams & Wilkins Co., 1943.

A HUNDRED YEARS OF MEDICINE. By C. D. Haagenensen and Wyndham E. B. Lloyd. New York: Sheridan House, 1943.

ORTHOPEDIC NURSING. By Robert V. Funsten, M.D. and Carmelita Calderwood, R.N. A.B. St. Louis: The C. V. Mosby Co., 1943.

BROUHAUSCH OF THE EYE, SLIT LAMP MICROSCOPY OF THE LIVING EYE. By M. L. Bergsma, M.D. Vol. New York and London: Paul B. Horber Inc., 1943.

CLINICAL DIAGNOSIS BY LABORATORY EXAMINATIONS. By John A. Kolmer, M.S., M.D. Dr. Phil. Sc.D. LL.D. L.H.D. F.A.C.P. New York and London: D. Appleton-Century Co., 1943.

SPECIALISTS IN MEDICAL PRACTICE. Edited by Edgar Van Noy Allen, M.D. With foreword by Donald C. Ballenger, M.D. Renewal pages for Vols. 1 and 2. New York and London: Thomas Nelson and Sons, 1943.

PROFUSION OF VASCULAR DISEASE (ANGIOLOGY). By Saul S. Sarnoff, A.M., M.D. Oxford Medical Outline Series. London, New York and Toronto: Oxford University Press, 1943.

PNEUMONIA. By Sylvia D. Maabach, M.D. Oxford Medical Outline Series. London, New York, and Toronto: Oxford University Press, 1943.

THE BIOCHEMISTRY OF MALIGNANT TUMORS. By Kurt Stern, M.D. and Robert Wilhelm, M.D. Brooklyn, N.Y.: Reference Press, 1943.

THE EDUCATION OF NURSES, HISTORICAL FOUNDATION OF MODERN TRENDS. By Isabel Mathland Stewart, R.N. A.M. New York: The Macmillan Co., 1943.

UROLOGY FOR NURSES. By Oswald Stansbury Lowrey, M.D., F.A.C.S., and Thomas Joseph Kurlin, M.D., F.A.C.S. Philadelphia, London, and Montreal: J. B. Lippincott Co., 1943.

CLINICAL LABORATORY METHODS AND DIAGNOSIS A TEXTBOOK ON LABORATORY PROCEDURES WITH THEIR INTERPRETATION. By R. B. H. Gradwohl, M.D. D.Sc. 3d ed. Vol. 1 and 2. St. Louis: The C. V. Mosby Co., 1943.

# SUBJECT INDEX TO VOLUME 77

- ABDOMEN**, Effects of rapid compression waves on animals submerged in water, 403, Traumatic wounds of, 601
- Abnormalities**, open bite, Y-shaped osteotomy for correction of, in adults, 40, congenital, Tripbalangeal thumb, report of 6 cases, 178, congenital, Omphalocele, anatomical and clinical considerations, 319
- Adrenal cortical extract**, Observations on transudate in intestinal strangulation I Effect of, on its toxicity, 605
- A-estradiol**, Effect of estrogenic substance upon uterine mobility during labor, study of 42 patients with Lóránd tograph, 433
- American College of Surgeons**—  
Clinical Congress, not to convene in 1943, 447  
Honorary fellowships conferred on distinguished Russian surgeons, 445  
Registry of Bone Sarcoma, Osteogenic sarcoma I Modified nomenclature and review of 118 five year cures, 413  
Tribute to doctors of North America, 448
- Amputation**, Atraumatic, through lower thigh, experiences with its use in peripheral vascular disease, 354
- Anastomosis**, Oblique, aseptic, end to-end ileac, procedure of choice in strangulating small bowel obstruction, 225
- Anesthesia**, spinal, So called "aseptic or chemical meningitis," report of 2 cases, 216
- Anesthesiology**, Modern, and anesthetist, ed 331
- Anesthetic agent**, "All out," for general anesthesia in armed forces and civilian defense, ed 437
- Anesthetists**, Modern anesthesiology and, ed 331
- Aneurysm**, Surgical treatment of acquired, and arteriovenous fistula of peripheral vessels, review of 67 cases, 462
- Angioma**, arterial, venous, "Malignant" hemangioma, 193
- Ankle**, sprains of, Novocain injection for minor injuries in military service, 397
- Aorta**, Aortic embolectomy, 157
- Arteries**, Prevention of gangrene following ligation of major, experimental study, 162, peripheral, Atraumatic amputation through lower thigh, experiences with its use in peripheral vascular disease, 354, Arterial blood supply of pancreas, 426, Surgical treatment of acquired aneurysm and arteriovenous fistula of peripheral vessels, review of 67 cases, 462
- Arthritis**, Study of derangement of semilunar cartilages based on 850 cases, 141
- Atelectasis**, postoperative, Bronchoscopy in treatment of, ed 435
- Autotransfusion**, Use of, in surgery of serous cavities, 167
- Azochloramid**, Chemical considerations governing the local chemotherapy of wound infections, 69
- BACTERIA**, Pyogenic sepsis, survey of 255 cases, 544
- Bacteriology**, Wound healing—experimental and statistical study V, and pathology in relation to suture material, 481
- Bad risk patient**, Umbilical hernia in, 514
- Bladder**, Value of stone dissolving agent, solution G, in treatment of alkaline incrustations of, lesions, 634, Reimplantation of ureter into, report of method applied to 10 patients, 585
- Blast injuries**, Thoracic injuries, review of cases, 271, immersion, Effects of rapid compression waves on animals submerged in water, 403
- Blood**, clotting of, Heparin tolerance, test of clotting mechanism, 31, whole, transfusion, Intravenous human plasma and serum therapy, cause of reactions with particular reference to use of concentrated plasma and serum, 113, Use of autotransfusion in surgery of serous cavities, 167
- Blood culture**, Pyogenic sepsis, survey of 255 cases, 544
- Blood flow**, Study of smaller blood vessels in burned dogs and cats, 348
- Blood pressure**, Use of methedrine in surgical operations, clinical study on effective pressor drug, 645
- Blood supply**, Prevention of gangrene following ligation of major arteries, experimental study, 162, Arterial, of pancreas, 426, Observations on transudate in intestinal strangulation I Effect of adrenal cortical extract on its toxicity, 605
- Blood vessels**, Evolution of circulation in developing femoral head and neck, anatomic study, 61, Hazards connected with treatment of varicose veins, 136, vasoconstriction, Study of smaller, in burned dogs and cats, 348, diseases of, Atraumatic amputation through lower thigh, experiences with its use in peripheral vascular disease, 354, peripheral vasoconstriction, High altitude frostbite, preliminary report, 561
- Bone**, Osteogenic sarcoma. I Modified nomenclature and review of 118 five year cures, 413, surgery, New type of, plate and screws, 595
- Brain**, One aspect of posttraumatic syndrome in cranio-cerebral injuries, 631
- Breast**, Mammary cancer in youth, 55, Cystosarcoma phylloides, with consideration of its more malignant variant, 279, Reconstruction of, deformities, 523
- Bronchiectasis**, Surgical treatment of, report on 76 patients, 315
- Bronchoscopy** in treatment of postoperative atelectasis, ed 435
- Bronchus**, Surgical treatment of bronchiectasis, report on 76 patients, 315, Esophagobronchial fistula, 615
- Burdenko**, Nicolai N, Honorary fellowships conferred on distinguished Russian surgeons, 445
- Burns**, Study of smaller blood vessels in burned dogs and cats, 348, Sulfanilamide ointment treatment of severe, 367
- CALCULUS**, dissolving agents, Value of, solution G, in treatment of alkaline incrustations of bladder lesions, 634
- Cancer**, Mammary, in youth, 55, uterine, diagnosis of, Value of vaginal smear in, 449, uterine, diagnosis of, Vaginal smear in, ed 557
- Catgut**, Wound healing—experimental and statistical study III Experimental observations, 243, IV Results, 376, V Bacteriology and pathology in relation to suture material, 481
- Chemotherapy**, Infections of urinary tract, ed 330, Pyogenic sepsis, survey of 255 cases, 544
- Chest**, Pleural empyema, ed 219
- Children**, Evolution of circulation in developing femoral head and neck, anatomic study, 61, Polypoid lesions of colon of, 639
- Cholecystitis** Acute obstructive, and application of principles of its rational treatment, 250, Acute, why opinions differ as to treatment, ed 674
- Circulation**, Evolution of, in developing femoral head and neck, anatomic study, 61

- Colon, Polypoid lesions of, children, 630  
Common bile duct, Mechanism of junction in cancer of pancreas, 99  
Compression *in vivo*, in water Effects of rapid on animals submerged, 403  
Cotton, Wound healing—experimental and statistical study III. Experimental observations, 343 IV. Results, 376 V. Bacteriology and pathology in relation to suture material, 48  
Cystosarcoma phyllodes, with consideration of its more malignant variants, 279

- DEFORMITIES**, congenital, Triphalangeal thumb, report of 6 cases, 76 Congenital dislocation of hip 1st special attention to after-cure period and late postreductive results, 307  
Dicoumarin, Heparin tolerance, test of clotting mechanism, 3  
Disks, Intervertebral, Protruded, 497  
Duodenum, Implantation of hepatic duct into, or stomach, 26 One stage pancreatoduodenectomy 51  
Dysmenorrhea, See menstruation

- EMBOLISM** of aorta, Aortic emblectomy 57  
Empyema, Pleural, ed. 219  
Endometriosis, Primary of cervix uteri, 376  
Esophagus, Gastrostomy for retrograde esophageal dilatation, leak proof dressing and method of concealing string, 42 Esophagobronchial fistula, 65  
Estrogens, Hysterol, comparative study of and methods of administration, 30  
Ethylol extrusion, Relief of essential dysmenorrhea, 657  
Extremity, lower, Half ring splint for fractures of femur and tibia and for other disabilities of, 518

- FEMUR**, Evolution of circulation in developing femoral head and neck, anatomic study 6; Half ring splint for fractures of and tibia and for other disabilities of lower extremity, 518 Treatment of intertrochanteric fractures of, the hanging cast, 598  
Fetus, Pregnancy in monkey after removal of, 539  
Fistula, arteriovenous, Surgical treatment of acquired aneurysm and of peripheral vessels, review of 67 cases, 46 Esophagobronchial, 65  
Flap, Radiodermatitis of head and neck 11th discussion of its surgical treatment, 384  
Foot, gangrene of, Atraumatic amputation through lower thigh, experience 11th Its use in peripheral vascular disease, 354  
Fracture, of zygoma, report of 7 consecutive cases, 960 of mandible, Horizontal pin fixation for using pin guide, 403 Half ring splint for of femur and tibia and for other disabilities of lower extremity 518 New type of bone plate and screws, 595 Intertrochanteric, Treatment of, of femur 11th hanging cast, 598 Frontalis, High altitude, preliminary report, 56

- GALL BLADDER** Acute obstructive cholecystitis and application of principles of its rational treatment, palpable mass clinical sign, Acute obstructive cholecystitis and application of principles of rational treatment, 50 Perforation of, study of 3 consecutive cases, 66 Acute cholecystitis—why opinions differ as to treatment, ed 74  
Gangrene, Prevention of, following ligation of major arteries—experimental study 6  
Gastrointestinal tract, cancer of, Metabolic studies in patients with, XI. Postoperative hypoproteinemia and relationship of serum protein fall to urinary nitrogen excretion, 6

- Gastrostomy for retrograde esophageal dilatation, leak proof dressing and method of concealing string, 42  
Graft, skin, Contact contact method of skin grafting as applied to human, 510 Same method of accelerated wound healing, ed. 535; Dermatomic pattern, and its use in reconstruction of hands, 6

- HANDS**, gangrene of, High altitude frontalis, 56  
Hemorrhage, report, 56; Dermatomic pattern graft and its use in reconstruction of, 6  
Head, Radiodermatitis of, and neck 11th discussion of its surgical treatment, 384  
Hemangiosarcoma, "Malignant," 93  
Hemorrhage, Massive gastric, ed. 95; Studies on therapy of hemorrhagic shock. I. Effects of iso-osmotic and of concentrated serum and plasma in normal dogs, 32 II. Effects of iso-osmotic and of concentrated serum and plasma in dehydrated dogs, 473; Manual removal of placenta, 553 Traumatic oozing of abdomen, 16  
Heparin, tolerance, test of clotting mechanism, 31  
Hepatic duct, Implantation of into duodenum or stomach, 26  
Hernia, Umbilical, in bad risk patient, 514 Inguinal, 1 of fascial sutures in, 539 Inguinal, Living fascial sutures in repair of, 535  
Hysterol, comparative study of estrogens and methods of administration, 30  
Hypertension, Intracranial, 46; Esophagobronchial, 65  
Initial skin incision 87 Congenital dislocation of, 11th special attention to after-cure period and late postreductive results, 307  
Hysterectomy Total, ed. 673

- PLEURIS**, Oblique, aseptic, end to-end flex anastomosis, procedure of choice in strangulating small bowel obstruction, 5  
Infection, Chemical considerations governing local chemotherapy of wound, 66; Pyogenic sepsis, survey of 23 cases, 544  
Larynx, minor, No death injection for its solitary seros, 397 craniocerebral, One aspect of posttraumatic syndrome in, 63  
Instruments and apparatus, Löffel tocomograph, Pattern of uterine mobility throughout labor with special reference to inertia, study of 99 patients with no antiostransfusion outfit, Use of, in surgery of sinus cavities, 67; Smith Peterson anal, Insertion of, without initial skin incision, 87 for relief of benign pneumothorax, Thoracic in Japan, review of cases, 575 Zimel chamber Study of venous blood vessel, burred dogs and cats, 343 Pressman urinary device, Gastrostomy for retrograde esophageal dilatation, leak proof dressing and method of concealing string, 42 Löffel tocomograph, Effect of uterine substance upon uterine mobility during labor study of 42 patients 11th, 433, Horizontal pin fixation for fractures of mandible using pin guide, 403 Half ring splint for fractures of femur and tibia and for other disabilities of lower extremity 518 Mammotomy, Use of fascial sutures in inguinal hernia, 539 Repair needle, Living fascial sutures in repair of inguinal hernia, 535 Green's therapeutic refrigerator, High altitude frontalis, preliminary report, 56 Bone plate and screws, New type of, 595 hanging cast, Treatment of intertrochanteric fractures of femur with, 518 Dermatomic pattern graft and its use in reconstruction of hands, 6

- Intestines, Metabolic studies in patients with cancer of gastrointestinal tract. XI. Postoperative hypoproteinemia and relationship of serum protein fall to

- unnary nitrogen excretion, 16, anastomosis, Oblique, aseptic, end to-end ileac, procedure of choice in strangulating small bowel obstruction, 225, obstruction, Oblique, aseptic, end to-end ileac anastomosis, procedure of choice in strangulating small bowel, 225, strangulated, Observations on transudate in, I Effect of adrenal cortical extract on its toxicity, 605, Volvulus of sigmoid colon, discussion of combined volvulus and hepatodiaphragmatic interposition, 669
- JAUNDICE**, Mechanism of, in cancer of pancreas, 199
- Jaw**, Y shaped osteotomy for correction of open bite in adults, 40, Osteochondroma of coronoid process of mandible, 51, Horizontal pin fixation for fractures of mandible using pin guide, 493
- KENNY** treatment, Reasons why orthodox is better than, of poliomyelitis, 389
- Kidney**, Ten years' experience with ribbon gut in urological surgery, 91, Malignant tumors of, surgical and prognostic significance of tumor thrombosis of renal vein, 295, Infections of urinary tract, ed 330, Reimplantation of ureter into bladder, report of method applied to 10 patients, 585
- Knee**, Posterior horn lesions in meniscal injury, 87, Study of derangement of semilunar cartilages based on 850 cases, 141, joint, New operative approach to, 344
- LABOR**, Pattern of uterine motility throughout labor with special reference to inertia, study of 105 patients with Lóránd tocograph, 101, Effect of estrogenic substance upon uterine motility during labor, study of 42 patients with Lóránd tocograph, 433, Manual removal of placenta, 553, Face and persistent brow presentations, 618
- Low back pain**, Herniation of nucleus pulposus, as complication of preexisting instability, 79
- Lower extremities**, gangrene and paralysis of, Prevention of gangrene following ligation of major arteries—experimental study, 162
- Lungs**, Surgical treatment of bronchiectasis, report on 76 patients, 315, Effects of rapid compression waves on animals submerged in water, 403, Bronchoscopy in treatment of postoperative atelectasis, ed 435
- MANDIBL**, See jaw
- Mecholyl** plus secretin, New test for pancreatic function II Experimental observations, 471
- meningitis**, So called aseptic or chemical, report of 2 cases, 216
- meniscus**, Posterior horn lesions in meniscal injury, 87
- menopause**, Hecetrol, comparative study of estrogens and methods of administration, 130
- menstruation**, Relief of essential dysmenorrhea with ethinyl estradiol, 657
- methedrine**, Use of, in surgical operations, clinical study on effective pressor drug, 645
- method**, transurethral resection, Young, prostatectomy
- Perineal prostatectomy** versus transurethral resection for hypertrophy and cancer of prostate, I Larsen
- Insertion of Smith Petersen nail** without initial skin incision, 187, Coonse Adams, New operative approach to knee joint, 344, Kenny Reasons why orthodox is better than, treatment of poliomyelitis, 389
- Press man**, Gastrostomy for retrograde esophageal dilatation, leak proof dressing and, of concealing string, 471, Sano, Coagulum contact, of skin grafting as applied to human grafts, 510, Sano, method of accelerated wound healing, ed 556, Brunswick, One stage pancreatoduodenectomy, 581
- Mortality**, maternal, Rupture of uterus analysis of 30 maternal deaths, 26, statistics, Mammary cancer in youth, 55, Umbilical hernia in bad risk patient, 514
- maternal, fetal**, Face and persistent brow presentations, 618, statistics, Perforation of gall bladder study of 25 consecutive cases, 601
- NECK**, Radiodermatitis of head and, with discussion of its surgical treatment, 284
- Nomenclature**, Osteogenic sarcoma. I Modified, and review of 118 five year cures, 413
- Novocain** injection, for minor injuries in military service, 397
- Nucleus pulposus**, Herniation of, as complication of preexisting low back instability, 79
- Nylon**, Wound healing—experimental and statistical study III Experimental observations, 245, IV Results, 376, V Bacteriology and pathology in relation to suture material, 481
- OBSTETRICS**, Rupture of uterus, analysis of 30 maternal deaths, 26, Roentgen pelvimetry, commentary, 153, Changes in extracellular water at delivery and in puerperium, 261, Effect of estrogenic substance upon uterine motility during labor, study of 42 patients with Lóránd tocograph, 433, Manual removal of placenta, 553, Face and persistent brow presentations, 618
- Omphalocele**, embryology of, anatomical and clinical considerations, 319
- Operation**, early, Acute cholecystitis, why opinions differ as to treatment, ed 674
- Osteochondroma**, of coronoid process of mandible, 51
- Ovary**, Hecetrol, comparative study of estrogens and methods of administration, 130
- PANCREAS**, cancer of, Mechanism of jaundice in cancer of, 199, Arterial blood supply of, 46 New test for pancreatic function II Experimental observations 471, One stage pancreatoduodenectomy, 581
- Pathology**, Wound healing—experimental and statistical study V Bacteriology and pathology in relation to suture material, 481
- Pelvis**, Roentgen pelvimetry, commentary 153
- Penis**, Avulsion of scrotum and skin of, technique of delayed and immediate repair, 326
- Placenta**, retention of, Pregnancy in monkey after removal of fetus, 539 Manual removal of, 553
- Plasma**, Intravenous human, and serum therapy, cause of reactions with particular reference to use of concentrated and serum, 113
- Plasma protein solutions** iso-osmotic versus concentrated Studies on therapy of hemorrhagic shock I Effects of, in normal dogs, 337, II Effects of, in dehydrated dogs, 475
- Poliomyelitis** Reasons why orthodox is better than Kenny treatment of 389
- Polypus**, Polypoid lesions of colon of children 630
- Portwine stain**, "Malignant" hemangioma 103
- Pregnancy**, Roentgen pelvimetry, commentary, 153 in monkey after removal of fetus 530
- Presentations** Face and persistent brow, 618
- Pressor agents**, Use of methedrine in surgical operations, clinical study on effective 645
- Prolapse**, uterovaginal, Surgical management of report of 730 personal operations 99
- Prostate**, cancer of, hypertrophy of, Perineal prostatectomy versus transurethral resection for hypertrophy and cancer of I Ten years' experience with ribbon gut in urological surgery 91

Prostatectomy, Perineal, cross trans-urethral resection for hypertrophy and cancer of prostate  
 Puerperium, Changes in extracellular water: 1. delivery and in, 26

**RADIODERMATITIS**, of head and neck with discussion of its surgical treatment, 354  
 Radon seed, introduction, "Malignant hemangioma, 93  
 Rectum, Polypoid lesions of colon of children, 630  
 Reduction, manipulative, Congenital dislocation of hip with special attention to after-care period and late postreductive results, 307  
 Roentgen pelviscopy commentary 53

**SARCOMA**, Osteogenic, I. Modified monochroite and review of 8 five year cases, 413  
 Sciatic pain, Herniation of nucleus pulposus, as complication of pre-existing low back instability 79  
 Scrotum, Avulsion of and skin of penis, technique of delayed and immediate repair 326  
 Semilunar cartilage, Study of denervation of, based on 850 cases, 4

Sepsis, See Infection  
 Serosa, cavities, Use of autotransfusion in surgery of serous cavities, 67

Serum, protein concentration, Metabolic studies in patients with cancer of gastrointestinal tract. VI. Postoperative hypoproteinemias and relationship of serum protein fall to urinary nitrogen excretion, 6  
 Intravenous human plasma and, therapy: cause of reaction with particular reference to use of concentrated plasma and serum, 3

Shock, posthemorrhagic, Studies on therapy of I. Effects of iso-osmotic and of concentrated serum and plasma in normal dogs, 337 II. Effects of iso-osmotic and of concentrated serum and plasma in dehydrated dogs, 475; surgical, Use of eufedrine in surgical operations, clinical study on effects: precursor drug, 443

Sigmoid colon, Valvulae of, dissection of combined of vides and hepatoduodenal ligament, 669

Skin, Wound healing—experimental and statistical study III. Experimental observations, 243 IV. Results, 370 V. Bacteriology and pathology in relation to suture material, 45

Skin graft, full thickness, Radiodermatitis of head and neck with discussion of its surgical treatment, 354  
 Avulsion of scrotum and skin of penis, technique of delayed and immediate repair 326

Solunar Vaginal, in diagnosis of uterine cancer 440, ed 557  
 Solution C, Value of stone dissolving agent, in treatment of alkaline incrustations of bladder lesions, 634

Spine, So called "aseptic or chemical myelitis," report of cases, 6  
 Protruded intervertebral disks, 407

Spleen, Maximal volume of human, 74  
 Staphylococcus aureus, effect on wound healing, Wound immunity 305

Stomach, Metabolic studies in patients: Ith cancer of gastrointestinal tract. VI. Postoperative hypoproteinemias and relationship of serum protein fall to urinary nitrogen excretion, 6  
 Cancer Treatment of gastric ulcer ulcer Treatment of gastric ulcer  
 Massive gastric hemorrhage, ed. 05  
 Implantation of hepatic duct into duodenum or 20  
 Gastrostomy for retrograde oesophageal dilatation, leak proof dressing and method of controlling string, 42

Sulfanilamide ointment, treatment of severe burns, 367  
 Sulfonamides, Chemical considerations governing local chemotherapy of wound infections, 64

Surgery, osteotomy Y-shaped, for correction of open bite in adults, 40  
 Ten years experience Ith

ribbons gut is neurological, 9  
 1 of serous cavities, Use of autotransfusion in, 67  
 Plastic, Radiodermatitis of head and neck Ith discussion of its surgical treatment, 354  
 Plastic, Avulsion of scrotum and skin of penis, technique of delayed and immediate repair 326  
 Plastic, Congenital contracture of skin grafting as applied to human grafts, 5  
 Plastic, Reconstruction of breast deformities, 5  
 Plastic, Dermotome pattern graft and its use in reconstruction of hands, 6

Suture material, Wound healing—experimental and statistical study III. Experimental observations, 243 IV. Results, 370 V. Bacteriology and pathology in relation to, 45

Sutures, ribbon gut, Ten years' experience Ith, is neurological surgery, 9  
 1 of Use of in inguinal hernia, 530  
 fascial, Living, 1  
 repair of inguinal hernia, 535

**TEMPERATURE**, basal body, Relief of essential dysmenorrhea Ith ethylol estradiol, 637

Tissue strength, Wound healing—experimental and statistical study III. Experimental observations, 243 IV. Results, 370 V. Bacteriology and pathology in relation to suture material, 45

Test, for pancreatic function, New II. Experimental observations, 47

Thigh, Arterio-canal amputation through lower experience with its use in peripheral vascular disease, 354

Thrombosis, Changes in extracellular: 1. at delivery and in puerperium, 26

Thorax, Thoracic injuries, review of cases, 37

Thromb, Tetraphaseal, report of 6 cases, 76

Tibia, Half ring splint for fractures of tibia and, and for other disabilities of lower extremity, 58

Tissue damage, High altitude frostbite: preliminary report, 55

Transverse, Observations on, in intestinal strangulation. I. Effect of adrenal cortical extract on its toxicity 605

Tumor, Malignant, of kidney, surgical and prognostic significance of tumor thrombosis of renal vein, 395

**ULCER**, peptic, Massive gastric hemorrhage ed. 05  
 Umbilical cord, Ombilicectomy, anatomical and clinical considerations, 39

Ureter, Reimplantation of into bladder: report of method applied to patients, 535

Urinary nitrogen excretion, Metabolic studies in patients with cancer of gastrointestinal tract. VI. Postoperative hypoproteinemias and relationship of serum protein fall to, 6

Urinary tract, Infections of, ed 330

Urine, alkaline, Value of stone dissolving agent, solution G, in treatment of alkaline incrustations of bladder lesions, 634

Uterus, Reproductive analysis of 30 maternal deaths, 26  
 contractions of Patterns of uterine motility throughout labor with special reference to inertia, study of 105 patients with Loring tocomograph, Surgical management of prolapse of and vagina, report of 730 personal operations, 200  
 Effect of estrogenic substance upon terine motility during labor study of 4 patients with Loring tocomograph, 433  
 cancer of Value of vaginal smear in diagnosis, 440  
 Vaginal smear in diagnosis of ed 557  
 cervix, Primary endometriosis of 376  
 Total hysterectomy ed 673

**VAGINA**, Surgical management of prolapse of uterus and, report of 730 personal operations, 200  
 Vaginal smear in diagnosis of uterine cancer ed 557  
 Primary endometriosis of cervix uteri 576





## BOOK REVIEWS

- ALEXANDER, EYDRE LOUVEY. Operating Room Techniques, 440.
- ANDERSON, W. A. D. Synopses of Pathology.
- ANDREWS, ALBERT H. JR. Manual of Oxygen Therapy. Techniques Involving Carbon Dioxide Helium, and Water Vapor, 44.
- BACOT, HARRY E. Essentials of Proctology, 335.
- BALLENGER, HOWARD CHARLES. A Manual of Otolaryngology and Laryngology, 2d ed., 6-8.
- BALLENGER, WILLIAM LINCOLN, and BALLENGER, HOWARD CHARLES. Diseases of the Nose, Throat and Ear. Medical and Surgical, 8th ed., 334.
- BARNES, ROGER W. Endoscopic Prostatic Surgery, 34.
- BARTOLI, GEORGE. Atlas of Ovarian Tumors, 1.
- BICK, ALFRED C. Obstetrical Practice, 3d ed., 413.
- BENNETT, GRANTVILLE, A., WATTS, H. W., and B. W. WATSON. Changes in the Knee Joint at Various Ages. With Particular Reference to the Nature and Development of Degenerative Joint Disease, 44.
- BERKELEY, SIR CONYERS, WHITE, CLIFFORD, and COOK, FRANK. Diseases of Women. Edited by Sir Conyers Berkeley, Clifford White, and Frank Cook, 7th ed., 97.
- BERKELEY, SIR CONYERS, and BOWEN, VICTOR. A Textbook of Gynaecological Surgery, 4th ed., 99.
- BOYD, WILLIAM. A Textbook of Pathology as an Introduction to Medicine, 4th ed., 560.
- BROWN, JAMES BAKER, and M. DOWELL, FRANK. Skin Grafting on Bones. Primary Cure, Treatment, Repair, 44.
- CHURCH, HENRY A. The Principles and Practice of Medicine Originally written by Sir William Osler, 14th ed., 97.
- COTTELL, ANDREW HALL. A Textbook of Gynaecology, 4th ed., 23.
- DELEE, JOSEPH B., and GREENWELL, J. P. The Principles and Practice of Obstetrics, 8th ed., 444.
- GOLDSTEIN, MORRIS A. Gynaecologic Surgery, 98.
- HAGGARD, CHARLES C. Royal Librarian, 115.
- HAYES, EDGAR ELLIOTT. Victories of Army Medicine. Scientific Accomplishments of the Medical Department of the United States Army, 677.
- HEDGECOCK, ELIZABETH. Cancer of the Uterus, 98.
- JONES, NORMAN R. Regional Analgesia for Intra-Abdominal Surgery; with Special Reference to Amethocaine Hydrochloride, 443.
- KENTON, JOSEPHINE HELEN. Healthy Babies are Happy Babies. Complete Handbook for Modern Mothers, 3d ed., 1.
- LAWRENCE, HENRIK O. Pancreatic Function and Pancreatic Disease: Studied by Means of Secretin. Translated by Helen D. Frey, 333.
- L. ANDREW KELLER, R. D., and PERCY. G. W. W. Implants and Artificial Limbs, 3.
- LEWIS, DR. AND S. R. V. The Sexual Glands of the Male.
- MAJOR, GUY. Fractures of the Jaws and Other Facial Bones, 3.
- MOORE, VANCE H. Shock. Its Dynamics, Occurrence and Management, 98.
- MORITZ, ALA. RICHARD. The Pathology of Trauma, 98.
- NATIONAL RESEARCH COUNCIL. Burns, Shock, Wound Healing and Vascular Injuries. Prepared under the auspices of the Committee on Surgery of the Division of Medical Sciences of the National Research Council, 33.
- Idem. Orthopedic Subjects. Prepared and edited by the Subcommittee on Orthopedic Surgery of the Committee on Surgery of the Division of Medical Sciences of the National Research Council, 44.
- Idem. Neurosurgery and Thoracic Surgery. Prepared and edited by the Subcommittee on Neurosurgery and Thoracic Surgery of the Committee on Surgery of the Division of Medical Sciences of the National Research Council, 50.
- NORTH, FIELD M. Transurethral Prostatectomy, 677.
- PARSONS, CHARLES F. The 943 Year Book of Industrial and Orthopedic Surgery. Edited by Charles F. Parsons, 99.
- PARSONS, CHARLES F. Synopses of Traumatic Injuries of the Face and Jaw, 107.
- QUICK, ARTHUR J. The Hemorrhagic Diseases and the Physiology of Hemostases, 99.
- R. V. R. W. The Treatment of Shock.
- RICHIE, MARTIN E. Indigestion, its Diagnosis and Management. With Special Reference to Diet, 3.
- RIGBY, LEO G. Outline of Roentgen Diagnosis, as Orientation to the Basic Principles of Diagnosis by the Roentgen Method, 2d ed., 677.
- T. C. J. The Principles and Practice of War Surgery. With Reference to the Biological Method of the Treatment of War Wounds and Fractures, 334.
- W. W. L. LAWRENCE R. Gynaecology. 11th Section on Female Urology, 440.
- WEINER, ALEXANDER S. Blood Groups and Transfusion, 3d ed., 560.
- The 943 Year Book of Industrial and Orthopedic Surgery. Edited by Charles F. Parsons, 99.
- ZIMM, LEO. Clotting plasma, 44.
- ZIMMER, HENRIK, and SELM, N. FALTY. The Antihemorrhagic Factor with Consideration of the Antihemorrhagic Problem.

